Research Topic

A study of the applications and challenges of digital assistants

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Abstract

Digital assistants are software used to automate tasks that are otherwise done manually. Digital assistants are used in various sectors like the aviation sector, the medical industry, research and development purposes, and decision making.

This research focused on studying digital assistants. This research aimed to study the trend of digital assistants in a real-world scenario. The research focused on obtaining information about the components used by digital assistants, the applications of digital assistants, and the challenges posed by digital assistants. To obtain this information, a structured literature review was conducted.

Statistical information from online sources was used to quantify the information. The process of collecting statistical data from online sources focused on obtaining the latest information about digital assistants. This process also involved getting information about the usage frequency of digital assistants.

An online survey was conducted to obtain a public opinion about digital assistants. This survey aimed to gather information about the user's point of view regarding the usefulness of digital assistants on a day-to-day basis.

Finally, the information obtained from the structured literature review, statistics from online sources, and public opinion from the survey were compared to test this research's hypotheses. This research followed the UTAUT model. The UTAUT model is used to study the acceptance of technology in the market. For this research, the UTAUT model was used to study the acceptance of digital assistants. The UTAUT model was used to analyse data based on age, gender, education, and profession. The research concluded that there is a positive trend in the adoption of digital assistants in the market. The public prefers using digital assistants and believes that digital assistants have a bright future. However, data privacy is a common concern of the users of digital assistants. This report describes the process undertaken to do this research.

Keywords: digital assistants, UTAUT, aviation, clinical research, data privacy

1. Introduction

Digital assistants are software that use various data processing concepts to provide information to users. The main aim of digital assistants is to automate tasks. Digital assistants are used in multiple domains, including aviation, medical research, corporate sector, entertainment, research and development, and the defence sector (Kennington & Shukla, 2017). Digital assistants, like other technologies, have a set of advantages, disadvantages, and limitations. Several kinds of research are going on to minimize the limitations of digital assistants like the threat to data privacy, possibility of a cyberattack, possibility of providing wrong information, and expanding their application base for domains like aviation, medical sector, corporate sector, and the defence sector (Ai, 2019; Jovanovic, Báez, & Casati, 2020; Sadeh et al., 2017). Along with applications, there are many risks involved in using digital assistants like concerns for data privacy, the possibility of cyber hacking, and overdependence on technology for simple routine tasks (Brill, Munoz, & Miller, 2019).

The research consists of the main research question followed by the sub research questions. The main research question aims to study the trend of digital assistants, whereas the sub-research questions aim to study the applications and challenges of digital assistants. Based on the research questions, the hypotheses of this research were derived. The study seeks to understand different components and technologies used in digital assistants, their integration with digital assistants, and their usefulness. The research also aims to study the applications of digital assistants in various sectors, and the efficiency of digital assistants to perform multiple tasks. Finally, the research focuses on the possible threats and challenges that may be possessed by digital assistants, the vulnerabilities of digital assistants, and the concerns of the users while using digital assistants. The analysis section of this research analyses the information collected during this research and uses it to answer the research questions.

The quantitative research method was used for this research. The research used descriptive analysis to systematically obtain information about the components and technologies used by digital assistants, the applications of digital assistants, and the challenges of digital assistants. For collecting data, this research conducted a structured literature review and obtained information from online sources. An online public survey was conducted for getting a public opinion about

digital assistants. The research aimed to study the trend of digital assistants. For this, the research used the UTAUT model to study the acceptance of digital assistants in the market. The analysis of the collected data was conducted based on the age group, gender, educational background, and professional background of the participants. The information obtained from the literature review, online survey, and online sources was compared to conclude. This research aims to bridge the knowledge gap between public opinion about digital assistants and the current research trends for digital assistants by gathering and analysing this information.

2. Literature Review

The aim of this research was to study the applications and challenges of digital assistants. As seen in the introduction section, digital assistants are used to automate tasks that would need to be done manually otherwise. The aim of conducting a systematic literature review was to establish a base for this research. The systematic literature review was divided into three main sections, namely components and technologies used by digital assistants, applications of digital assistants, and the challenges of digital assistants. Scholarly databases like ACM, semantic scholar, EBSCOhost, and science direct were used for conducting this literature review. The relevancy of the information obtained was decided based on the publication year, citations received, and the research findings of the articles. Keywords and search terms like “applications of digital assistants”, “components of digital assistants”, “AI and digital assistants”, “AI in aviation”, “application domains of digital assistants”, “decision making in digital assistants”, “digital assistants and cybersecurity”, “digital assistants performance in the market” and “future of digital assistants” were used to find relevant information for this research. The flow of the literature review can be found below.

Flow diagram for the literature:

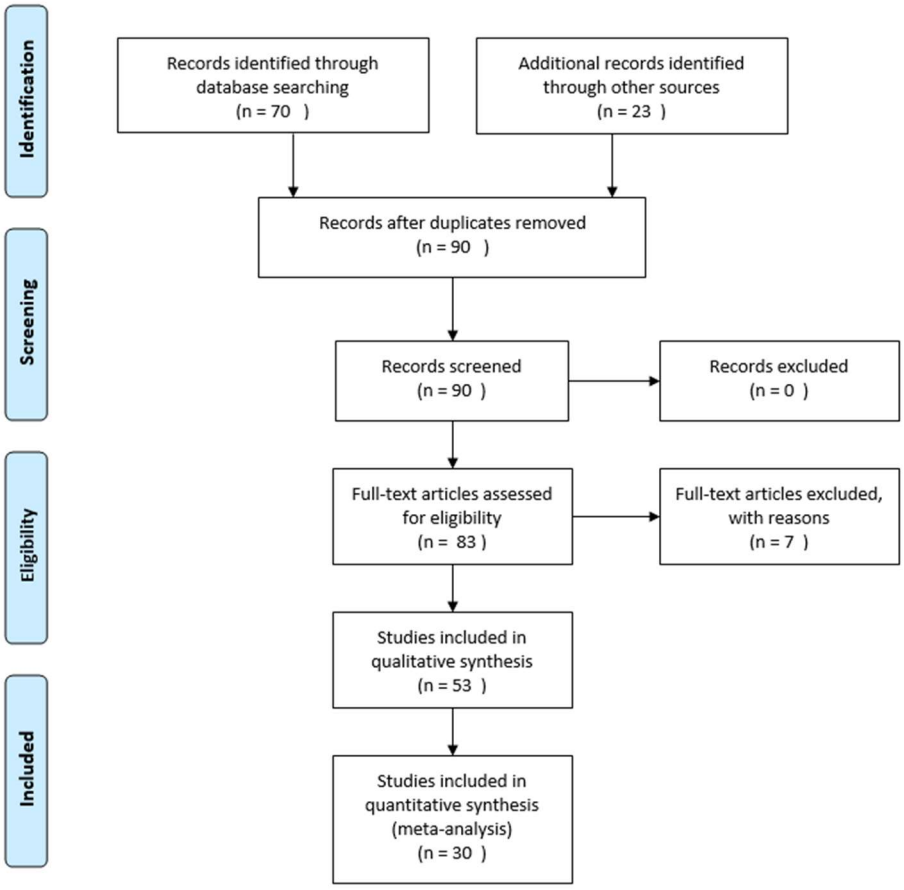

Figure 1 Prisma flow diagram for the literature review("http://www.prisma-statement.org/," 2021)

For constructing the flow diagram, a Prisma checklist was created. The Prisma checklist contains parameters to verify the validity of the reference for given research. The Prisma checklist and the flow diagram are available as templates on the Prisma statement website. For this research, the inclusion criteria were based on the relevancy of the information obtained from the references, the time when the articles were approved and the relation of the information in the articles to this research. The articles' inclusion criteria were that the article should be no more than five years old, should be peer-reviewed, and should be in the English language. The initial literature search obtained 93 articles. From the obtained articles, 13 were found to be either irrelevant or were redundant. Hence, they were eliminated from the literature review. The remaining 90 articles were analysed, keeping any hypotheses of this research regarding digital assistants in

consideration, and were found to be relevant to the research topic. This research examined quantitative, qualitative, experimental, descriptive, and mixed research articles in the research approach.

The literature review for this research was focused on the below-given topics:

- Components and technologies used by digital assistants
- Applications of digital assistants
- Challenges posed by using digital assistants.

Mind Map for the Structured Literature Review

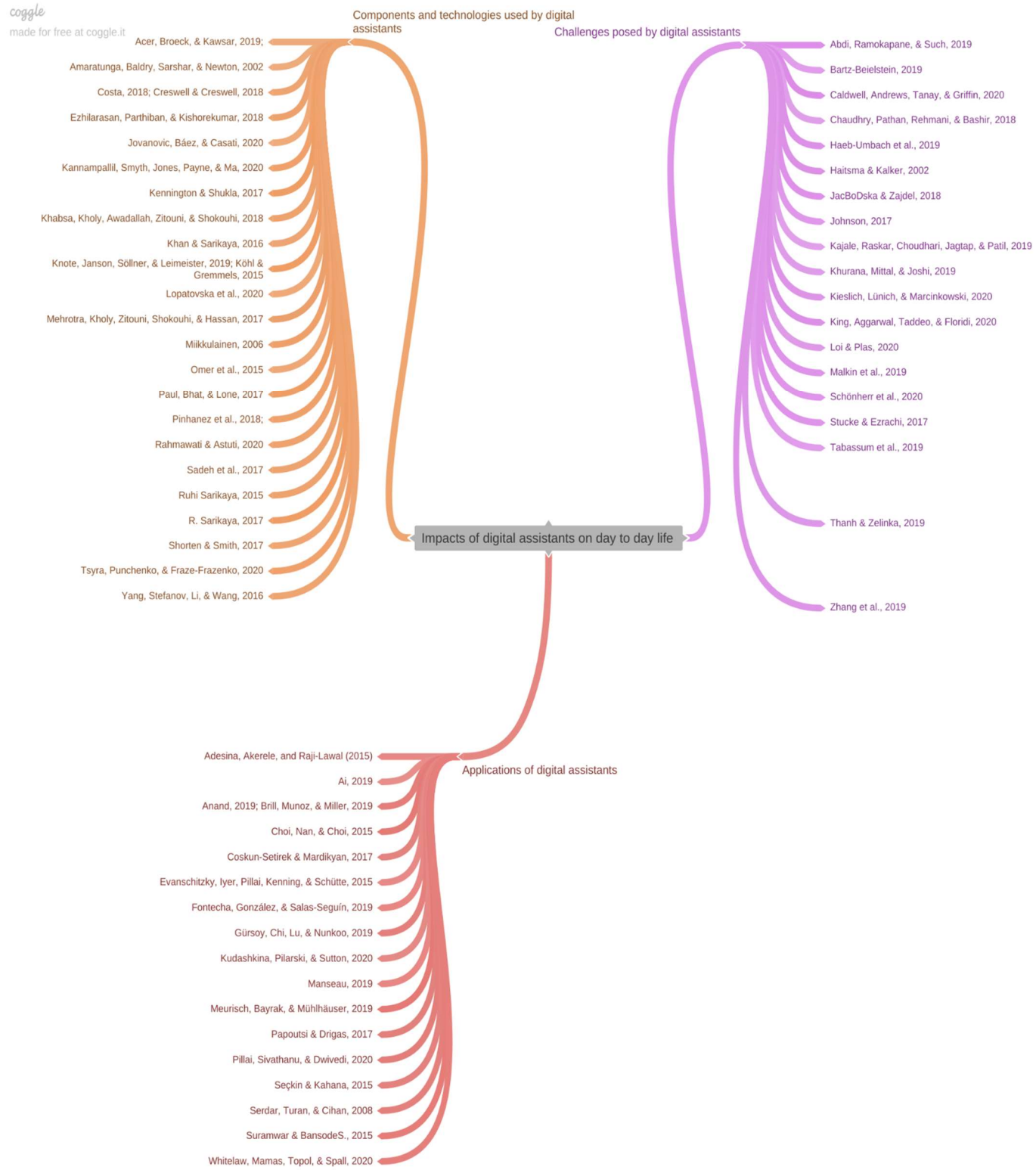

Figure 2: Mind map for the literature review("Coggle," 2020)

2.1 Components and Technologies used by Digital Assistants

This phase focused on gathering information about the technologies by digital assistants, various approaches to implement digital assistants, technologies before digital assistants, the possibility of future research concerning digital assistants, and the functioning of digital assistants.

Table 1: Literature review: Components and technologies used by digital assistants

No.	Author	Title	Findings	Type of research	Connection to this research
1	Khan and Sarikaya (2016)	Making Personal Digital Assistants aware of what they do not know	Proposal to improve the efficiency of digital assistants to manage web-based data.	Quantitative	Proposal to improve the functioning of digital assistants
	Köhl and Gremmels (2015)	A software tool for the input and management of phenotypic data using personal digital assistants and other mobile devices	A new interfacing tool using PDA features to process phenomic data	Experimental	Integration of digital assistants based on user requirements
3	Miikkulainen (2006)	Creating intelligent agents in games	Recommendation for the use of artificial intelligence and data processing in games	Descriptive	Integration of artificial intelligence, neural networks, and data processing into the software to improve their quality and productivity
4	Mehrotra, Kholy, Zitouni, Shokouhi, and Hassan (2017)	Identifying user sessions in interactions with intelligent digital assistants	Discussion for the session cut off times for digital assistants	Experimental	Recommendation for calculating and altering the existing session cut off times for digital assistants to improve productivity
5	Khabsa, Kholy, Awadallah, Zitouni, and Shokouhi (2018)	Identifying task boundaries in digital assistants	Study of various sessions and recommendation of a custom-made machine-learned model to improve	Quantitative	Analysis of the performance of digital assistants during various user sessions. Proposal to use a custom-made model to

			the overall productivity of digital assistants		recommend various alterations to digital assistants to improve the work efficiency of the digital assistants
6	Ruhi Sarikaya (2015)	The Technology Powering Personal Digital Assistants	Recommendation of best practices for digital assistants to support their transition from testing laboratories to consumers	Experimental	List of best practices for digital assistants who can ensure appropriate performance of digital assistants
7	Tsyra, Punchenko, and Fraze-Frazenko (2020)	Features of construction and basic directions of development of virtual digital assistants	Analysis of various technologies used to make digital assistants and recommend multiple domains of applications for digital assistants	Descriptive	The article studies various components and technologies used by digital assistants. The article also studies the concepts of these technologies to recommend potential application domains for digital assistants
8	Costa (2018)	Conversing with personal digital assistants: on gender and artificial intelligence	Study of various digital assistants and chatbots to understand why the majority of digital assistants are designed to resemble a female	Descriptive	List of probable reasons for digital assistants to be resembling female attributes such as voice
9	Knote, Janson, Söllner, and Leimeister (2019)	Classifying smart personal assistants: an empirical cluster analysis	Classification of various types of digital assistants based on their functionalities	Descriptive	Description of various types of personal assistants and elaborates their functionalities
10	Pinhanez et al. (2018)	Different but equal: Comparing user collaboration with digital personal assistants vs teams of expert agents	Comparison of the functioning of digital assistants and chatbots to discover the difference in working and efficiency for given tasks	Experimental	Comparison of chatbots and digital assistants for similar tasks and compares their performance and work efficiency

11	Lopatovska et al. (2020)	User recommendations for intelligent personal assistants	Study of user needs for digital assistants to recommend various modifications that can be done to digital assistants to improve their efficiency	Qualitative	Description of user needs for digital assistants, various changes that can be made in digital assistants to improve digital assistants' performance, and proposal of a list of changes that can be done to make digital assistants more flexible
12	Kannampallil, Smyth, Jones, Payne, and Ma (2020)	Cognitive plausibility in voice-based AI health counselors	Proposal for two models of voice assistants and test them for their efficiency	Experimental	Description of the potential of voice assistants to act as choice counselors to expand the scope of voice assistants and improve seamless interaction with the users.
13	Paul, Bhat, and Lone (2017)	Cortana-Intelligent personal digital assistant: a review	Study of various techniques and processes used by digital assistants for speech recognition and interpretation.	Quantitative	Description of the importance of speech recognition techniques to ensure the efficiency of digital assistants, through the review and proposal for a logical base on which future research can be carried out
14	Rahmawati and Astuti (2020)	PDA (Personal digital assistant) effectiveness towards music learning results	Study of the effectiveness of digital assistants in supporting users learning music	Quantitative	Proposal for a sequence of steps to identify and analyse possible challenges the users face in learning music. Based on the collected information, the users survey to obtain public opinion
15	Kennington and Shukla (2017)	A graphical personal digital assistant that grounds and learns autonomously	Development of a voice-based personal digital assistant that learns from the	Experimental	Development of a personal assistant that can autonomously gather data and learn from it based on user interactions, and

			interactions with the users		testing the efficiency of the voice assistant for an itinerary filling task
16	Acer, Broeck, and Kawsar (2019)	The city as a personal assistant	Proposal for a new type of digital assistant constrained by the granularity of the location of the users	Experimental	Identification of the need for digital assistants in every part of the city and proposal of the system architecture and concept of a digital assistant that is based on a particular location
17	Ezhilarasan, Parthiban, and Kishorekumar (2018)	Intelligent drone-based personal assistant using artificial intelligence (AI)	Providing the design for mobile personal digital assistants that use Arduino, raspberry pi, text to speech, and ultraviolet sensors to function	Experimental	Proposal for a new type of digital assistants who can move based on voice commands and can avoid obstacles
18	(Yang, Stefanov, Li, & Wang, 2016)	Applying a built-in virtual personal assistant for educational equipment	Proposal for a new model of a digital assistant that can be integrated with multiple software platforms to improve the learning process's efficiency.	Experimental	Study of various software products used for providing digital training, and proposal for a new model of digital assistant which can be integrated into the software models to enhance the learning process efficiency
19	(Sadeh et al., 2017)	A privacy assistant for the Internet of things	Proposal for a digital assistant that can guide the users regarding data privacy and can support them to control the privacy settings of their respective devices	Experimental	Proposal for a digital assistant that monitors data sharing and information access settings of the user devices. The researchers propose a new digital assistant particularly focused on privacy configuration of user devices
20	Jovanovic et al. (2020)	Chatbots as conversational healthcare services	A literature review and analysis of medical chatbots	Qualitative	Study of the existing healthcare chatbots to derive the functional characteristics and

			to study the possibility of improvement in personalised healthcare		benefits of using chatbots. The researchers also provide a set of points that can support the improvement of healthcare chatbots

Discussion for Literature Review about the Components and Technologies used by Digital Assistants

This section was focused on obtaining information about technologies like speech recognition and neural networks that are used by digital assistants. The aim of getting information about the components and technologies used by digital assistants was to understand the functioning and to discover the possibility for improvement in digital assistants. Based on the conducted literature review for obtaining information about the components and technologies used by digital assistants, the following information was obtained.

Digital assistants aim to support effective communication between the users and intelligent systems by using concepts of artificial intelligence, machine learning, and deep learning (Tsyra et al., 2020). Digital assistants use a combination of predefined head domains and the functionality to obtain information from the Internet to provide a fallback response to users (Khan & Sarikaya, 2016). In case of digital assistants being unable to provide relevant data to the users, the digital assistants use dialogue logic to decide whether to notify the user of its limitation or to redirect the user to a web location containing related data (Khan & Sarikaya, 2016). Digital assistants interact with databases, stored libraries, websites, and the data inputted by the users to obtain a solution based on user requirements (Köhl & Gremmels, 2015). Digital assistants can be trained on user interactions with the computers by using the concepts and techniques of neural networks, machine learning and can also be used to develop unique products based on the insights of the user interactions (Miikkulainen, 2006). Digital assistants like websites use session cut-offs to monitor user interactions (Mehrotra et al., 2017). The user sessions are distributed into segments based on user interaction to identify and establish the task boundaries for the digital assistant (Khabsa et al., 2018). To process the commands given in natural language, digital assistants use structured data, machine learning concepts, and computational logic to improve overall work productivity. Improvement in speech recognition, device feedback,

knowledge of the hardware of personal assistants, and the knowledge of the context of digital assistants are the recommendations collected from the users (Lopatovska et al., 2020). Digital assistants can also be implemented at public places to provide information regarding area, nearby places and monitor the user activities at the place of installation (Acer et al., 2019). Digital assistants use text-to-speech converters and microprocessors to process information (Ezhilarasan et al., 2018). Digital assistants can be integrated with various sensors and hardware to implement a smart mechanism to assist students (Yang et al., 2016). Digital assistants can work in heterogeneous Internet of Things (IoT) based environments and collect data in various formats (Sadeh et al., 2017).

2.2 Applications of Digital Assistants

This phase focused on obtaining information on the application domains of digital assistants, benefits, and demerits of using digital assistants and the most common digital assistants' applications.

Table 2: Literature review: Applications of digital assistants

No.	Author	Title	Findings	Type of research	Connection to this research
1	(Serdar, Turan, & Cihan, 2008)	Rapid access to information resources in clinical biochemistry: medical applications of personal digital assistants (PDA)	A review of 11 software products used in the medical industry for their effectiveness in assisting laboratory specialists by providing data	Experimental	Comparison of various approaches to simultaneously process data and assist healthcare professionals
2	Brill et al. (2019)	Siri, Alexa, and other digital assistants: a study of customer satisfaction with	A survey using PLS-SEM method to analyse the satisfaction of the users for a set of	Quantitative	Derivation of the statistical significance of satisfaction of using digital assistants and analysis of user

		artificial intelligence applications	popular digital assistants		satisfaction for the functionalities offered by digital assistants
3	Manseau (2019)	AI in the workplace: the case of intelligent employee assistants	Study of the applications of intelligent employee assistants, review of interactions of employees and intelligent employee assistants to derive their usefulness. And the productivity of intelligent employee assistants	Experimental	Analysis of the performance of intelligent employee assistants in workplaces and observation of the issues faced by intelligent employee assistants in processing natural language commands issued by the users
4	Pillai, Sivathanu, and Dwivedi (2020)	Shopping intentions at AI-powered automated retail stores	Study of the implementation of AI for standalone stores to study human intentions while interacting with technology in the store	Experimental	Review of the trust of users for digital assistants and a test of the efficiency of digital assistants to operate in standalone environments
5	Evanschitzky, Iyer, Pillai, Kenning, and Schütte (2015)	Consumer trial, continuous use and economic benefits of retail service innovation: the case of a personal shopping assistant	Proposal for implementing personal shopping assistants in stores and a review for the acceptance and productivity of personal shopping assistants by implementing them in a test environment	Experimental	Proposal for implementation of personal shopping assistants in stores to increase store productivity and can benefit both retailers and customers.
6	(Gürsoy, Chi, Lu, & Nunkoo, 2019)	Consumers acceptance of artificially intelligent (AI) device use in service delivery	A study of the acceptance of digital assistants in the real world using three stages of testing to determine the probability of the users to accept AI systems	Quantitative	Calculation of the probability of acceptance for digital assistants in real-world situations based on the target population to check if they will accept digital assistants' inclusion for service delivery.

7	(Meurisch, Bayrak, & Mühlhäuser, 2019)	EdgeBox: confidential ad-hoc personalisation of nearby IoT applications	The researchers propose a new model to ensure a personalised experience for users on public IoT devices.	Experimental	A study for preserving user privacy and safeguarding the machine learning concepts and logic in public places and a proposal for a new model for implementing IoT devices in public that meets the above section's safety requirements.
8	Vieira (2017)	Business applications of deep learning	Proposal of a set of algorithms, concepts, and logics used in deep learning to populate a list of most common business applications of deep learning and discover the logic behind the applications.	Descriptive	Implementation of deep learning tools and concepts in business environments, elaboration of the significance of deep learning, and description of a list of applications for the tools developed using deep learning concepts.
9	Fontecha, González, and Salas-Seguín (2019)	Using conversational assistants and connected devices to promote responsible energy consumption at home	Proposal for a smart home setup having a digital assistant to enable responsible energy consumption at home by using functionalities provided by the digital assistants.	Experiment	Information on the integration of digital assistants with household appliances, the recommendation for using digital assistants to monitor energy usage related data.
10	Coskun-Setirek and Mardikyan (2017)	Understanding the adoption of voice-activated personal assistants	A study of the factors which affect the performance of voice assistants by conducting a survey	Quantitative	Establishment of statistical significance by surveying a group of participants to determine the possibility of improvement in voice-activated

					assistants and a study of the benefits and challenges of digital assistants and the public satisfaction of using digital assistants.
11	Kudashkina, Pilarski, and Sutton (2020)	Document-editing assistants and model-based reinforcement learning as a path to conversational AI	Comparison of various document editing approaches used by digital assistants	Descriptive	Information about the use of digital assistants for interaction and interpretation.
12	Seçkin and Kahana (2015)	Smartphone health applications	Study of the trend in the use of smartphones for patient care to understand the reason for increasing demand and use of smartphone applications for medical and clinical purposes	Descriptive	A study of various digital assistants' applications embedded to smartphones for providing clinical and health-related support to the users.
13	Anand (2019)	Autonomous cars (embedded systems)	A study of various components of embedded systems used to manufacture an autonomous car to identify the trend in research of various embedded systems-related technologies.	Descriptive	Information about the applications of digital assistants in the automotive industry used to implement embedded systems and their components into an automobile to make them autonomous.
14	Papoutsi and Drigas (2017)	Empathy and mobile applications	A study of various approaches for implementing systems to imitate empathy by altering various configurations of digital assistants	Qualitative	This research is important as it focuses on the human factor of digital assistants. The researchers discuss the approaches that can be used to imitate

					empathy by the digital assistants.
15	Purwanto, Kuswandi, and Fatmah (2020)	Interactive applications with artificial intelligence: the role of trust among digital assistant users	Information about the role of trust among the users of digital assistants and a study of a set of digital assistants to determine the factors which play a crucial role in developing the user trust for digital assistants.	Quantitative	This research is important as it studies the trust of users in digital assistants. This research helps to predict the possibility of acceptance of digital assistants in the future.
16	Ai (2019)	Research on knowledge management of aviation manufacturing industry based on association rules	Proposal for a model for knowledge management in China's aviation.	Descriptive	Proposal for knowledge management and data management system to improve the efficiency of the aviation manufacturing sector in China.
17	Whitelaw, Mamas, Topol, and Spall (2020)	Applications of digital technology in covid-19 pandemic planning and response	Research on the implementation of digital technologies to support business continuity.	Descriptive	Information on the frameworks adopted by various nations to tackle the pandemic situation.
18	Adesina, Akerele, and Raji-Lawal (2015)	Using mobile communication as a tool for national growth and development	Study on the ways that mobile applications, their behaviour, and performance	Descriptive	A list of digital assistants' applications and broaden the scope of application for digital assistants.
19	Choi, Nan, and Choi (2015)	Advances in smart and intelligent multimedia platforms for pervasive computing	Discussion of the possibilities of integrating security and surveillance systems in various environments to enhance monitoring and control	Descriptive	Study of various technologies that can be integrated with other hardware mechanisms in the workplace.
20	Suramwar and	A survey on different types of intrusion	Discussion of various approaches to improve the existing	Quantitative	Comparison of the shortlisted applications that

	BansodeS. (2015)	detection systems	intrusion development and management software		support intrusion detection.

Discussion of The Literature Review for the Applications of Digital Assistants

The aim of finding literature regarding the applications of digital assistants was to discover the uses of digital assistants in various sectors. This section of the literature review focused on obtaining information about the sectors in which digital assistants are used, the possibility of expansion of the application domain of digital assistants, and the common applications of digital assistants. Based on the reviewed literature, the following information was obtained.

Digital assistants assist users with disabilities with environment control activities such as temperature control, ambience control, operating machines based on user commands, data management and also help in health management activities like monitoring heart rate, pulse rate, body temperature, providing medication-related reminders, and also help in other daily activities like calling friends and family, receiving, reading and sending emails and messages and for entertainment (Koon, Blocker, & Rogers, 2019; Serdar et al., 2008). Digital assistants are used for making commercial software that can assist medical professionals by providing information about the patient, medical history, surgical history, prescribed medications, and possible treatments for a given medical case (Serdar et al., 2008). Digital assistants are integrated with the concepts of neural networks to improve the operational efficiency of the aviation sector (Cheng, Wen, & Li, 2016). Digital assistants provide an interactive experience to the customers while performing daily personal tasks like navigation, entertainment activities, and data processing (Brill et al., 2019). Digital assistants are configured to assist employees at the workplace by automating tasks like email composition, document processing, note taking, and appointment handling to increase employee performance (Manseau, 2019). Digital assistants can be installed in retail stores to automate tasks like billing, communication with the customer, stock management, monitoring the machines installed in the store, and handling replacements and refunds (Pillai et al., 2020). Digital assistants are used as personal shopping assistants by the users to automatically compare the prices of commodities in various shops and outlets, study the existing and upcoming sale offers and assist the customer with maintaining a wish list of the things they wish to buy and this feature can also help the store operators to increase their revenue

(Evanschitzky et al., 2015). Digital assistants support the implementation of real-time and ad-hoc processing for the ubiquitous devices while maintaining the confidentiality of the user data and the frameworks and logic used to implement the functionality (Meurisch et al., 2019). Digital assistants are integrated with concepts and logic of deep learning to assist in business operations, data processing, image processing, voice processing, automating vehicles and can also be configured to provide insights based on the processed data to assist in the decision-making process (Vieira, 2017). Digital assistants can be connected with embedded systems to implement environment control by monitoring the power consumption of the installed devices, checking for power leakages, providing suggestions based on the usage patterns, automatically managing the devices connected to the network, connecting the devices present in the home network or office network to the Internet, enhancing the user experience by automating certain tasks like automatically turning the device on and off and changing modes of operations which would otherwise need to be done manually (Fontecha et al., 2019). Digital assistants are integrated with the sensors and processors in the vehicle and can be used to implement autopilot systems (Anand, 2019). Digital assistants are used in aircraft, ships, and other vehicles to monitor the functioning of various parts of the vehicle and control the overall performance of the vehicle (Anand, 2019). Digital assistants are used in manufacturing facilities to monitor the performance of the machinery, monitor the manufacturing process, and for providing insights about the possible improvements that can be implemented to increase the efficiency of the manufacturing facility (Ai, 2019). Digital assistants are being used for responding to the present pandemic situation for tracking the spread of infection, monitoring the health of patients, monitoring the manufacturing process of the vaccines, providing insights about the possible treatments based on the data collected from the patients and medical professionals and by assisting the clinical researchers by providing possible solutions for the treatment of patients (Whitelaw et al., 2020). Digital assistants are integrated into computing environments like government websites and physical environments like banks, offices, and public places to monitor and assist the security professionals in ensuring the safety of the environment, people, and the information of that environment (Suramwar & BansodeS., 2015).

2.3 Challenges Posed by Digital Assistants:

In this section, the challenges faced by users in using digital assistants are discussed. Also, possible drawbacks of using digital assistants, threats posed by digital assistants, and the vulnerabilities of digital assistants are discussed.

Table3: Literature review: Challenges posed by digital assistants

No.	Author	Title	Findings	Type of research	Connection to this research
1	(Haeb-Umbach et al., 2019)	Speech processing for digital home assistants: combining signal processing with deep learning techniques	Description of the importance of various hardware and software components used to process signals for smart home devices	Descriptive	The limitations faced by the embedded components directly affect the overall performance of digital assistants.
2	Stucke and Ezrachi (2017)	How digital assistants can harm our economy, privacy, and democracy	Description of various threats that may be posed by digital assistants and discussion on the possibility of overdependence on technology and describe the possible threats digital assistants may possess.	Descriptive	Discussion about the possible threats of using digital assistants.
3	Abdi, Ramokapane, and Such (2019)	More than smart speakers: security, and privacy perceptions of smart home personal assistants	Discussion on the knowledge gap in customers using smart home assistants and determine the possible threats posed by digital assistants' lack of knowledge.	Qualitative	Discussion about the possible threats that may be due to a lack of knowledge of the structure of smart home assistants.
4	Chaudhry, Pathan,	Threats to critical infrastructure	Arguments on the possibility of a seamless transition	Descriptive	Description of various viewpoints that oppose

	Rehmani, and Bashir (2018)	form AI and human intelligence	of the workforce and the technology's reliability.		technology implementation to replace human activities and proposal for inclusion of technology to improve overall work efficiency in the real-world scenario.
5	Johnson (2017)	The weaponization of AI: a glimpse into future threats	The researchers review three articles and compare them to study the possibility of threats posed by artificially intelligent devices	Descriptive	Description of possible risks and threats posed by the implementation of artificial intelligence into the real-world scenario and discussion about the excessive use of artificial intelligence to improve their performance.
6	Schönherr et al. (2020)	Unacceptable, where is my privacy? Exploring accidental triggers of smart speakers	An experiment to discover trigger commands similar to the original wake up commands for smart speakers and a description of the possibility of a threat of data privacy due to constant signal processing by the smart speakers.	Experimental	Description of the continuous data gathering process by smart devices, discussion on the possibility of data privacy infringement resulting from this continuous data gathering process.
7	Zeng, Mare, and Roesner (2017)	End-user security and privacy concerns with smart homes	Study of home environments embedded with smart home devices to discover knowledge gaps and possible threats to insufficient technical knowledge.	Experimental	Analysis of the possible challenges digital assistants might face security and discussion about the possibility of malfunction, cyber-attacks, and other forms of threats.
8	Haitsma and Kalker (2002)	A highly robust audio	Description of an audio fingerprinting	Descriptive	This research is important as it can be

		fingerprinting system	system that saves particular audio and uses it to discover patterns related to it from the available data sources		critical in digital assistants saving user's audio commands. This research highlights the challenge of maintaining data security for the user information stored by digital assistants.
9	(Zhang et al., 2019)	Dangerous skills: understanding and mitigating security risks of voice-controlled third-party functions on virtual personal assistant systems	Discussion about the threat of masquerading attacks on smart home devices and proposal for a voice squatting device that can be used to tackle attacks on personal voice assistants.	Experimental	Description of various flaws in personal voice assistants that make them vulnerable to attacks.
10	Tabassum et al. (2019)	Investigating user's preferences and expectations for always-listening voice assistants	A survey to discover user opinions for personal assistants.	Qualitative	Description of the preferences of users with digital assistants and discussion about the approaches of digital assistants which the users do not prefer.
11	Malkin et al. (2019)	Privacy attitudes of smart speaker users	A survey for a group of smart speaker users regarding their data privacy concerns.	Qualitative	Study on the concerns of users of digital assistants regarding the data digital assistants collect, and their lack of knowledge about data retention policies.
12	(Caldwell, Andrews, Tanay, & Griffin, 2020)	AI-enabled future crime	Description of crimes that can be committed using artificial intelligence in the future.	Descriptive	Discussion about the possibility of the use of AI to undertake criminal activities.
13	Kajale, Raskar, Choudhari,	Survey on securing data with blockchain and AI	Proposal for a new approach to share critical medical information securely	Experimental	Description of the need for data security in the field of cloud computing.

	Jagtap, and Patil (2019)		over the cloud platform		
14	Bartz-Beielstein (2019)	Why we need an AI-resilient society	Discussion about the need for an AI-resilient society.	Descriptive	Description of the possible threats to the users of AI technology and proposal of approaches that can help safeguard users from possible threats caused by artificially intelligent devices.
15	Khurana, Mittal, and Joshi (2019)	Preventing poisoning attacks on AI-based threat intelligence systems	Discussion about inspecting the information gathered from various sources regarding attack prevention.	Descriptive	Discussion about the challenges faced by digital assistants and proposal for a model to tackle this.
16	JacBoDska and Zajdel (2018)	Artificial intelligence and the Internet of things for sustainable development: emerging technological and social opportunities and threats	A survey on the possibility of threats that may occur by the widescale implementation of artificial intelligence in the global market	Qualitative	A study of the current market scenario regarding artificially intelligent devices and analysis of the possible risks that may occur by introducing AI-based devices into the market scenario.
17	King, Aggarwal, Taddeo, and Floridi (2020)	Artificial intelligence crime: an interdisciplinary analysis of foreseeable threats and solutions	A study of the possible risks of using digital assistants and provide a list of approaches that can be taken to design the future approach.	Descriptive	Discussion of the future aspects of AI-based devices and description of the threats of using various components included in digital assistants.
18	(Thanh & Zelinka, 2019)	A survey on artificial intelligence in malware as next-generation threats	Proposal for a new mechanism to counter cyber threats of artificially intelligent devices.	Experimental	Description of the possible threats to digital assistants and a list of guidelines for safeguarding the digital assistants and surrounding environment

19	Loi and Plas (2020)	A blind spot of AI ethics: antifragility in statistical prediction	Description of various challenges faced by users in decision making because of using artificially intelligent devices	Descriptive	Description of the loss of the ability of decision making because of excessive use of digital assistants.
20	Kieslich, Lünich, and Marcinkowski (2020)	Threats of artificial intelligence scale (TAI). Development, Measurement, and Test over three application domains	Discussion of various types of threats that may occur due to using artificially intelligent mechanisms in various domains	Quantitative	Proposal for a scale to measure the possibility of threat using artificially intelligent mechanisms and devices in the real-world scenario.

Discussion about the Literature Review for the Challenges posed by Digital Assistants

This component of the literature review aimed to obtain information about the possible challenges and threats posed by digital assistants. This component focused on understanding the vulnerabilities of digital assistants and the possibility of a threat to the users of digital assistants. Based on the analysis of the information obtained from the literature review, the following information was obtained.

Digital assistants can make the users overly dependent on technology, can give them biased information and can pose a threat of data privacy infringement to the users, and can also pose challenges like inability to interpret given commands and failure to provide relevant information (Bogers et al., 2019). Digital assistants pose a threat to the professionals whose work can be automated by the use of digital assistants and also create a need for professionals experienced in handling digital assistants (Mesquita, Oliveira, & Sequeira, 2019). Digital assistants to support command-based activation, process all the possible information inputted by the voice input sensor, lead to a sense of insecurity regarding data privacy and confidentiality for the users (Abdi et al., 2019; Stucke & Ezrachi, 2017). Digital assistants can also create an environment where powerful platforms can dominate developing platforms that can lead to a monopoly of a limited number of platforms in the market (Stucke & Ezrachi, 2017). Digital assistants lack the understanding of the concepts of emotional intelligence, innovation, and creativity, limiting their

actions to monotonous tasks (Chaudhry et al., 2018). Digital assistants are vulnerable to cyber threats and the possibility of system hacks as they remain connected to the Internet for their functioning (Zeng et al., 2017). Digital assistants use the concept of audio fingerprinting to identify their users, and this concept can pose a threat in case the audio fingerprint of the user is leaked or is stolen from the database and can lead to a cyber threat (Haitsma & Kalker, 2002). Based on the received input, digital assistants may redirect the users to a malicious link on the Internet which may be harmful to the user's privacy and confidentiality (Zhang et al., 2019). There is a possibility that because digital assistants continuously remain active and record the communication going on in the background, there is a possibility of a hacker eavesdropping on the communication of the users (Tabassum et al., 2019). Digital assistants can be configured and used to attack establishments, networks, and offices. They can also be used to hinder the normal functioning of factories, manufacturing units, and home and work environments (Caldwell et al., 2020). Inefficient security measures and unencrypted information stored by digital assistants on the cloud can be vulnerable to a cyber threat (Kajale et al., 2019). Digital assistants can be embedded with AI-based machines and weapons to increase their efficiency, thus risking the security of the users (Bartz-Beielstein, 2019).

2.4 Summary of the Structured Literature Review:

Digital assistants use various concepts, including data mining, voice recognition, and deep learning to function (Ezhilarasan et al., 2018). When the user gives a command in the form of voice, gesture, and through the interface, the digital assistant processes it to create a set of expected outputs. The command is then processed against the available data in the cloud or the device based on the nature of the command. Digital assistants also use learning methods such as pattern recognition, storing historical information, and using various algorithms (Mesquita et al., 2019).

To provide a personalized experience, digital assistants store personal information. This helps provide the user with relevant content and promotions and helps the digital assistant reduce the turnover time (Sadeh et al., 2017).

Studies are going on to improve digital assistants' efficiency to accept, interpret, and process the user commands. Digital assistants also use decision support systems, recommender systems, and neural networks to process the received commands. Studies are also going to ensure the security of user information stored in digital assistants (Lopatovska et al., 2020).

Digital assistants are used to automate various tasks. Digital assistants are used in the aviation sector, medical sector, corporate organizations, personal use, and research and development purposes. Users feel that digital assistants improve work efficiency. Moreover, digital assistants also help save time and effort for routine tasks (Coskun-Setirek & Mardikyan, 2017).

Digital assistants, like other technologies, have sets of advantages and disadvantages. Digital assistants rely on a combination of technologies and sources to function. Security of digital assistants poses a challenge in real-world use. Digital assistants store user information to enhance user interactions and to learn from the interaction patterns. This literature reviewed shows that digital assistants are vulnerable to cyber threats (Thanh & Zelinka, 2019). Users are concerned about data privacy threats that digital assistants might pose (Schönherr et al., 2020). Digital assistants rely on user commands for functioning, and for this, the input sensors such as the voice sensor, motion sensor, and gesture sensor are always active (Zhang et al., 2019). This may lead to digital assistants storing the user data which the user does not consent to provide. Digital

assistants embed themselves with other devices present in the functional space. It becomes a threat if the digital assistant is hacked by other devices installed in that particular environment, maybe at risk (King et al., 2020). Digital assistants may also be risky to use in case of places where confidential information is processed like banks, defence establishments, and boardrooms (Caldwell et al., 2020). Digital assistants can sometimes provide false or incomplete information for a user query, and this malfunction can lead to risks in work environments where information processing is crucial (Khurana et al., 2019).

3. Methodology

3.1 Problem Statement

This research is focused on digital assistants. Digital assistants can be used to automate the tasks which may otherwise need to be done manually. Digital assistants are in demand because of their ease of use, productivity, and work efficiency they add for a user (Kennington & Shukla, 2017). Studies are being conducted to expand the application base of digital assistants. Although being productive, digital assistants have advantages and disadvantages. Digital assistants are not safe from cyber-attacks and malfunctions. Digital assistants, based on their functionalities like recording user information, can also challenge the user's privacy (Abdi et al., 2019).

Along with data privacy, digital assistants may also pose a challenge by providing wrong information and making users overly dependent on technology (Johnson, 2017). Lack of knowledge about digital assistants is also a threat to the efficiency of digital assistants. Users cannot utilize digital assistants if they do not know about digital assistants. Hence, this research aimed at obtaining information about the components and applications of digital assistants. By obtaining information about the features used to make digital assistants and the functionalities provided by digital assistants, it may be possible to eliminate the challenges posed by digital assistants due to the lack of knowledge of the user. Moreover, this research also involved conducting an online survey to obtain information about user preferences for using digital assistants. Along with finding the components used for making digital assistants and their applications, this research also focuses on obtaining information about digital assistants' possible application domains.

3.2 Research Design

Research design is the overall strategy for conducting the research. The main aim of establishing a research design is to get evidence for addressing the research gap and the need for a solution using a logical and simple approach (Labaree, 2020).

Based on the nature of the research, research design can be divided into the categories given below (Creswell & Creswell, 2018):

- Qualitative research design
    - Qualitative research contains a central research topic and aims to expand the scope of the conclusion based on the collected data (Amaratunga, Baldry, Sarshar, & Newton, 2002)
    - Qualitative research uses interviews, focus groups, and observations to collect information
    - This research cannot use the qualitative approach as it needs to derive a conclusion about digital assistants. The qualitative approach aims to collect information about a given topic to expand the knowledge base. Hence, it is not suitable for this research.

- Quantitative research design
    - Quantitative research approach aims to derive a conclusion based on the available data (Amaratunga et al., 2002)
    - Quantitative research approach uses a series of experiments and descriptive analysis to collect and analyse information about the given topic
    - This research aimed to collect information about digital assistants to test the hypotheses. The quantitative research approach fits the requirement of this research.
    - Based on the requirements of this research, the descriptive research design was selected for this research. Information about the descriptive research design can be found below.

    - **Descriptive research design**
    - Descriptive research aims to provide systematic information about a given topic/entity or a phenomenon
    - Descriptive research aims to systematically collect information about the selected topic to test the hypotheses

    - Based on the analysis of collected information, the solution is determined, and the research is concluded

- Mixed methods research
    - Mixed methods research combines both qualitative and quantitative research approaches to get the output of the result (Shorten & Smith, 2017)
    - Mixed methods approach uses the output of a qualitative research method to gather as much information as possible to establish the research base. It then uses the quantitative research approach to filter out unnecessary information to derive a finite logical conclusion
    - The mixed-methods approach aims to use the concepts of both qualitative and quantitative research methods. This research cannot use mixed methods approach as the main aim of this research is to obtain information about the applications of digital assistants, components used in digital assistants, and the challenges posed by digital assistants
    - This research aims at deriving public opinion about digital assistants from the collected data. Hence, quantitative research is a suitable approach for this research. Quantitative research will help in focusing on the main hypotheses and will be useful to derive valuable insights to determine the conclusion.

This research involves collecting data from multiple sources and comparing them with the hypotheses to discover commonalities between the collected data to conclude this research. Hence, it is essential to do a systematic data collection that will help in determining the basis of the research. Thus, descriptive analysis is suitable for this research. The descriptive analysis approach will help in collecting relevant data to test the hypotheses of this research.

Justification of the Selected Research Method:

For this research, the quantitative research method is suitable. The quantitative research method focuses on quantifying the available data to justify the undertaken research. For this research, the aim of using the quantitative research method was to keep this research focused on digital assistants. The research involved collecting information about the technologies and concepts used by digital assistants, public opinion about digital assistants, information about the applications, and possible challenges and threats of digital assistants. The research involved discovering commonalities between the collected information to conclude this research. Hence, there was a possibility of this research going out of the research scope because of the amount of information collected from various sources. Therefore, the quantitative research method was selected for this research as it can help in collecting data from multiple sources and can also guide in filtering the available data to conclude. Moreover, the quantitative research method can also help in determining and maintaining the research scope and can help in working on data from multiple sources.

Following the quantitative research method, this research also aimed to discover commonalities between the collected data. Hence, this research aimed to provide precise information about the components and technologies used, applications and challenges of digital assistants. Therefore, descriptive analysis was selected for this research. The descriptive analysis method focuses on systematically collecting information about a given topic. For this research, the descriptive analysis was used to represent the commonalities obtained by comparing the information obtained from the literature review, the online survey, and the information obtained from the online sources.

3.3 Research Objective

The research objective helps to understand the expectations of the research. The main aim of this research is to study the trend of digital assistants. By conducting this research, the below-given topics are to be explored:

- Public opinion about the efficiency of digital assistants (Brill et al., 2019)

    - The aim of getting a public opinion about the efficiency of digital assistants was to understand the demand for digital assistants in the real-world scenario
    - By understanding the need for digital assistants, this research aims to predict the future of digital assistants
- Public opinion about the usefulness of digital assistants (Gürsoy et al., 2019)
    - The aim of getting public view about the usefulness of digital assistants was to determine the possibility of acceptance of digital assistants
    - By obtaining information regarding the usefulness of digital assistants, this research aimed to check if the users find digital assistants to be productive
- Primary uses of digital assistants (Purwanto et al., 2020)
    - The aim of obtaining information about the uses of digital assistants was to determine the type of functionalities of digital assistants expected by the public
- Public opinion about the safety of digital assistants (Tabassum et al., 2019)
    - By obtaining a user perspective about the safety of digital assistants, this research aimed to understand the user's level of trust in digital assistants
- Prediction of the possible application sectors of digital assistants (Lopatovska et al., 2020).
    - This question aimed at obtaining information about the likeliness of users to accept digital assistants
    - This question aimed at understanding the level of support of users for digital assistants.

For achieving the objectives mentioned above, this research used a structured literature review, a general survey, and collect data from various reputable sources to determine the conclusion for the statements given above.

3.4 Research Questions

Main Research Question:

- What are the factors that affect the use of digital assistants in day-to-day life?

Description:

This question aims to interrogate the efficiency of digital assistants from a public point of view. This answer to this question will be used to obtain and analyse relevant information related to the objectives mentioned above.

Sub Research Questions:

1. What are the standard application domains of digital assistants?
    - This question aims to study the outcome of the structured literature review to establish the basis for this research
    - From the answer to this question, it will be possible to obtain the most common applications of digital assistants that are utilised by the public
    - This question will also help in determining the need for digital assistants in various domains.
2. Which are the sectors that can utilise digital assistants?
    - This question aims to study the need for digital assistants in various domains
    - The answer to this question will be helpful to determine the possible domains where the public would prefer to use digital assistants.
    - This question aimed to determine the possible domains in which users would like to see digital assistants being implemented.
3. What are the challenges faced by the users in using digital assistants?
    - This question aims to study the weaknesses and demerits of digital assistants
    - The answer to this question will help in determining the possible threats of using digital assistants
    - This question will also help establish a base on which further research can be done to determine and improve digital assistants' safety.

3.5 Hypotheses

This research contains the hypotheses given below:

H1. Gender influences the performance expectancy of digital assistants

H2. Age influences the performance expectancy of digital assistants

H3. All genders are positively affected by the effort expectancy of digital assistants

H4. All age groups are positively affected by the effort expectancy of digital assistants

H5. Users having work experience are positively affected by the effort expectancy of digital assistants

H6. Social influence has a positive effect on users towards using digital assistants

H7. Social influence of digital assistants positively affects users of all age groups

H8. Experience of using digital assistants has a positive effect on the social influence of digital assistants

H9. Social influence positively affects the voluntariness of use of digital assistants

H10. Facilitating conditions positively affect users of all age groups to use digital assistants

H11. Facilitating conditions have a positive impact on users with prior work experience on digital assistants

H12. Behavioural intention affects the performance expectancy of digital assistants

H13. Effort expectancy affects the behavioural intention for digital assistants

H14. Social influence has a positive effect on the behavioural intention for digital assistants

H15. Facilitating conditions positively affect the behavioural use of digital assistants

H16. Behavioural intention influences the behavioural use towards digital assistants.

These hypotheses are created using the information obtained from the literature review. The hypotheses also consider the research objectives. The research questions and hypotheses are related and share common research expectations. The survey questions are also derived based on these hypotheses and are aimed to obtain answers that can test the research objectives.

3.6 Theoretical Framework

A research model is a systematic approach used for the research. The research model acts as an outline for the research and guides the research process. The main aim of using a research model is to improve research efficiency (Farooq, 2019). The Unified Theory of acceptance model or the UTAUT model is suitable for this research as it supports considering multiple analysis parameters. Further elaboration for the UTAUT model is given below.

UTAUT Model

UTAUT stands for the Unified Theory of Acceptance and Use of Technology. This model aims to understand user intentions for using a particular technology (Venkatesh, Thong, & Xu, 2016). Moreover, this model also aims to study the behaviour of the users while using the given technology. The UTAUT model can be seen below in Figure 3.

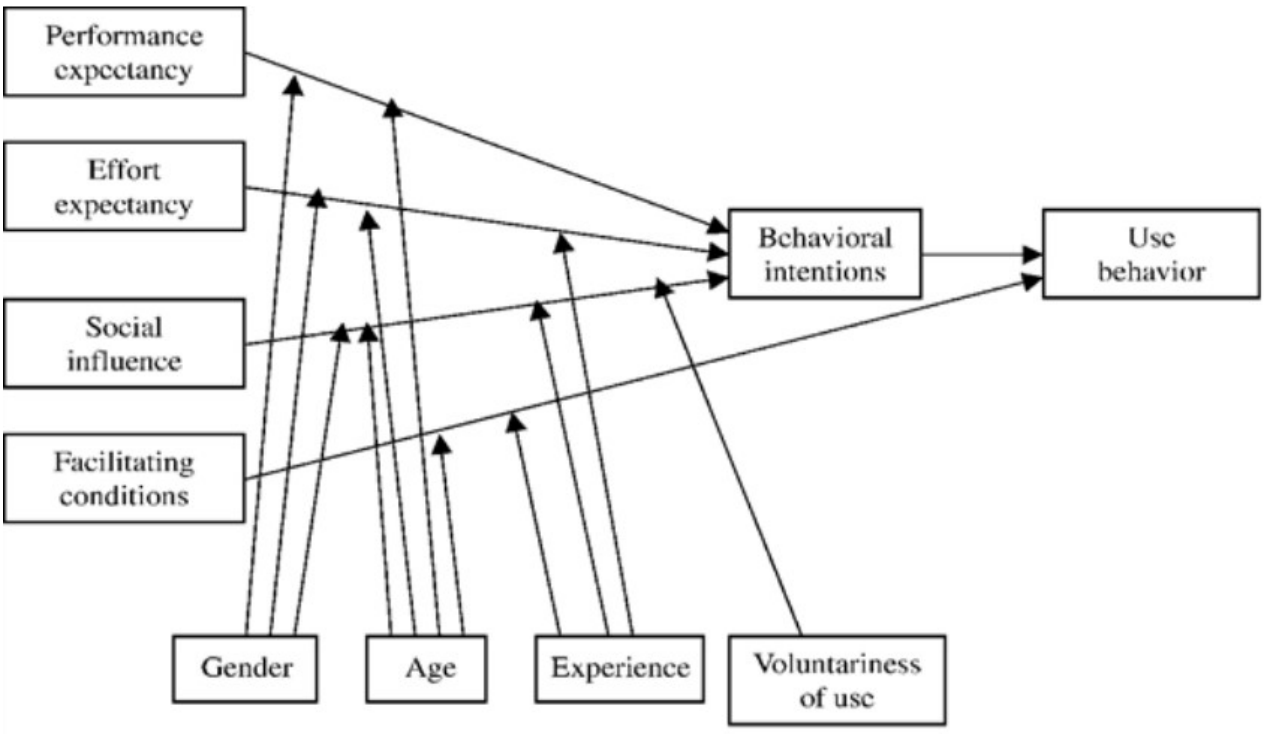

Figure 3 UTAUT model (Venkatesh et al., 2016)

The UTAUT model takes the gender, age, work experience, and the intention of the users to use the given technology as parameters to analyse user intentions. The UTAUT model contains a set of determinants and moderators calculated to get an output (Omer et al., 2015). The determinants and moderators are further elaborated below.

- Determinants:
    - Performance expectancy:
        - Performance expectancy is the measure of the extent to which a user believes that the given technology will help them to perform their duties
        - Performance expectancy is used to calculate the improvement in work in using the selected technology
        - Performance expectancy calculates the degree of enhancement done to the work using the selected technology
        - Performance expectancy also calculates the positive impacts of implementing the selected technology in an organisation
        - Performance expectancy calculates the extent of use of the technology for a given organisation.

    - Effort Expectancy:
        - Effort expectancy is the measure of the ease of access to a given technology based on a user's point of view
        - Effort expectancy calculates how easy it is to use the selected technology for users
        - Effort expectancy also measures how stressful it is to interact with the technology
        - Effort expectance also considers the importance of using the selected technology for a given organisation.

    - Social Influence:
        - Social influence is the degree of social pressure experienced by the user to use the selected technology
        - Social influence checks how useful is the technology for other users

        - Social influence also considers the frequency and intensity of use of the selected technology by society
        - Social influence also considers the motivation and encouragement to use the selected technology experienced by the user.

    - Facilitating Conditions:
        - Facilitating conditions represent the degree of availability of a given technology
        - Facilitating conditions checks if the users have sufficient knowledge to interact with and to operate the given technology
        - Facilitating conditions also consider the ease of implementing or introducing the selected technology in a given environment.

- Moderators:
    - Gender
        - Gender helps in identifying first-hand information regarding the preference and need for using a given technology
    - Age
        - Age helps understand the degree of acceptance of the given technology based on various age groups of the society
    - Experience
        - Experience or Work Experience can help understand the need for technology and assist in determining the demand for implementation of the selected technology in various sectors
    - Voluntariness of Use
        - Voluntariness of use refers to the urge or preference for using a given technology by the user. The voluntariness of use can help in determining the acceptance rate and the possibility of the success of the selected technology in the introduced environment.

- Co-relation in between the determinants and the moderators:

Table 4: Correlation between the determinants and the moderators in UTAUT

Moderators	Determinants
Gender	Performance Expectancy, Effort Expectancy, and Social Influence
Age	Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions
Experience	Effort Expectancy, Social Influence, and Facilitating Conditions
Voluntary Use	Social Influence

Based on the information given above, the UTAUT model calculates the behavioural intention and the user behaviour for the selected technology. The components used to calculate them are given below.

- User Intention:
    - Performance Expectancy
    - Effort Expectancy
    - Social Influence
    - Gender
    - Age
    - Experience
    - Voluntary use.
- User Behaviour:
    - Facilitating Conditions
    - Age
    - Experience.

Contribution of UTAUT for this Research:

The UTAUT model is used to check the user intention and user behaviour for a given technology based on various parameters. This research aims to review the usefulness, ease of use, and possible digital assistants' threats based on public review. Hence, the UTAUT model's outline can be used to calculate the determinants for digital assistants. The information obtained from the survey, data collected from online sources, and the data obtained from the literature review can be combined and compared with the hypotheses of this research to determine digital assistants' usefulness.

The UTAUT model also considers various moderators to analyse the degree of acceptance of the given technology in a given environment. This concept can analyse information obtained from multiple sources to determine the degree of digital assistants' acceptance.

The co-relation of determinants and moderators in the UTAUT model and the hypotheses for this research is given below:

Table 5: Comparison of the hypotheses for this research with the UTAUT model

Variable	Factor	Hypothesis
Gender	Performance Expectancy	H1. Gender influences the performance expectancy of digital assistants
Age	Performance Expectancy	H2. Age influences the performance expectancy of digital assistants
Gender	Effort Expectancy	H3. All genders are positively affected by the effort expectancy of digital assistants
Age	Effort Expectancy	H4. All age groups are positively affected by the

		effort expectancy of digital assistants
Experience	Effort Expectancy	H5. Users having work experience are positively affected by the effort expectancy of digital assistants
Gender	Social influence	H6. Social influence has a positive effect on users towards using digital assistants
Age	Social influence	H7. Social influence of digital assistants positively affects users of all age groups
Experience	Social influence	H8. Experience of using digital assistants has a positive effect on the social influence of digital assistants
Voluntariness of use	Social influence	H9. Social influence positively affects the voluntariness of use of digital assistants
Age	Facilitating Conditions	H10. Facilitating conditions positively affect users of all age groups to use digital assistants
Experience	Facilitating Conditions	H11. Facilitating conditions have a positive impact on users with prior work experience on digital assistants

Behavioural Intention	Performance Expectancy	H12. Behavioural intention affects the performance expectancy of digital assistants
Behavioural Intention	Effort Expectancy	H13. Effort expectancy affects the behavioural intention for digital assistants
Behavioural Intention	Social Influence	H14. Social influence has a positive effect on the behavioural intention for digital assistants
Use Behaviour	Facilitating Conditions	H15. Facilitating conditions positively affect the user behaviour for digital assistants
Use Behaviour	Behavioural Intention	H16. Behavioural intention influences the use of behaviour towards digital assistants

Use of UTAUT for this Research

The UTAUT model works by analysing various moderators and determinants to obtain insights about a given topic. The UTAUT model aims to study the acceptance of a given technology. For this research, the selected technology is digital assistants. The analysis phase of this research involves comparing data obtained from different sources. Filtering the available data can help in obtaining various insights for this research. Hence, the quantitative research method is being used for this research. The research aims to study the trend of digital assistants based on the parameters like age group, professional background, educational background, and gender. The UTAUT model includes studying all these parameters to calculate the performance expectancy, effort expectancy, voluntariness of use, and social influence of the given technology. Hence, the UTAUT model fits the parameters of this research. Moreover, the UTAUT model aims to

understand the acceptance of a given technology in a real-world scenario. For this research, the aim is to understand the trend of digital assistants. Hence, the UTAUT model can be implemented in this research. To analyse the moderators and determinants for this research, the information obtained from the online survey, online sources, and literature review can be used. The moderators and determinants can help determine the effectiveness, popularity, and the productivity of digital assistants based on the collected data.

3.7 Data Collection

A research tool is anything that can help in conducting the research. A research tool's main aim is to assist the researcher in making the research efficient ("Definition of research tool | different forms of research tool," 2015). The research tools used in this research and their functions are given below.

- Literature review
    - A literature review is a systematic process of collecting relevant information about previously undertaken researches about a given topic (Houston & Blenchard, 2020)
    - The literature review was used to establish a knowledge base for this research
    - The literature review was mainly focused on getting information regarding digital assistants, public opinion about the use of digital assistants, and the trend of digital assistants.
- Online Survey
    - An online survey was conducted for this research to gather public opinion for digital assistants
    - The questions of the survey were focused on the hypotheses of this research and semantics of the UTAUT model
    - The survey's output was compared with the information obtained from the literature review and the data collection from online sources to conclude the research.

- Data collection from Internet sources

- The main aim of data collection was to get statistics about digital assistants
- These statistics were mainly collected from the websites of the companies that manufacture and sell digital assistant-based systems
- The information gathered from the data collection process was compared with the information obtained from the literature review and online survey to test this research's hypotheses.

3.8 Research Approach

The research approach is a collection of systematic steps taken to undertake and complete the research. The research approach aims to keep the research focused on the research topic and improve overall research efficiency.

The approach followed for this research is given below.

Figure 4: Research approach for this research

The above-given figure shows the research approach followed in conducting this research. The research involved conducting a literature review, an online survey and data collection from online resources. Literature review aimed to learn about the advancements in research and implementation of digital assistants in various domains and to obtain information about how the

digital assistants can are being used in the real-world market scenario. The literature review focused on obtaining information on the technologies and concepts used by digital assistants, various applications for which digital assistants can be used, and obtaining information about the challenges and threats of using digital assistants. The information obtained from the literature review was considered as a base for this research. The reason for considering the information obtained from the literature review is the relevancy and acceptance of the sources from which this information was obtained. Based on the information obtained from the literature review, the online survey was framed to obtain information from the public. The online survey aimed to obtain a public opinion about the information collected from the literature review. The information obtained from the online survey was mapped with the information collected from the literature review to understand the current trend of digital assistants. The information obtained from online sources was used as an additional parameter to compare the information obtained from the literature review and the online survey. The information obtained by comparing the information obtained from the literature review, online survey, and the information obtained from the online sources was used to conclude this research.

3.9 Population

Qualtrics population calculator was used for calculating the sample size required for this research. The calculation can be seen below.

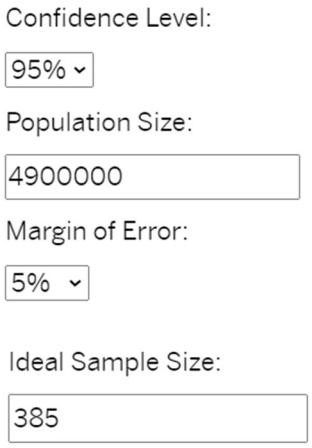

Figure 5: Sample size calculation for this research

3.10 Sampling Method

This research focuses on the overall public as the target audience. This online survey aims to obtain a public opinion about the usefulness of digital assistants. Hence, the convenience sampling method is suitable for this research, as there is no specific target group to be tested or analysed.

The convenience method for data sampling focuses on collecting information from wherever possible instead of considering additional parameters or requirements. Hence, it supports the researcher to focus more on analysis instead of data collection (Dudovskiy, 2020).

The calculation done on the Qualtrics sample size calculator based on the population requires at least 385 responses for the sample size to be statistically significant. The responses received by conducting the online survey was 62. Hence, the number of responses recorded do not meet the required sample size for statistical significance. The responses received from the survey were helped in supporting the hypotheses.

The process of collecting statistical data from online sources focused on obtaining information about the usage statistics of digital assistants, the popularity of digital assistants, and digital assistants' overall performance in the real-world scenario. The process of collecting statistical data from online sources was done to study digital assistants' current market conditions. The information obtained from this research was analysed using a sub-grouping analysis method.

3.11 Reliability of Data

All the data obtained from the literature review was peer-reviewed. The data were filtered to suit the relevance of the research topic. Moreover, the data obtained were compared with the hypotheses to ensure the relevancy of the research objective.

The data obtained from the online survey was collected from participants belonging to various backgrounds. Qualtrics was used to launch and record the survey and responses. Before using the gathered information, the data was formatted to remove any possible redundancies and errors.

The data gathering process to gather statistics related to digital assistants used the data available on the company websites, research papers, and other famous online sources.

3.12 Validity of Data

The data used for this research was shortlisted based on the hypotheses to be tested. The collected data was from trustworthy and notable sources and was used without alterations. The data obtained from the survey was used as it is, and only redundant or erroneous data was removed to improve the clarity of results.

3.13 Data Gathering

The data gathering for this research was done in three steps. The data gathering process is elaborated below.

3.13.1 Literature Review

The literature review focused on gathering relevant information regarding the below-given topics:

- Components and technologies used by digital assistants
    - The main focus of this topic was to understand the composition of digital assistants
    - The main aim of this step is to understand various concepts, tools, and technologies used by digital assistants to function
    - By collecting data about the components related to digital assistants, in-depth knowledge can be gained about the possible applications of digital assistants, benefits of using digital assistants, and potential challenges that may be faced while using digital assistants.
- Applications of digital assistants:
    - This step focused on discovering application domains of digital assistants
    - The main aim of this step was to find the domains in which digital assistants are commonly used and to discover the benefits of using digital assistants
    - This step also focused on discovering potential application domains of digital assistants and considered further research that can be undertaken for digital assistants.
- Challenges of using digital assistants
    - This step aims to gather information regarding the threats that digital assistants may incur
    - This step also takes the demerits of digital assistants into account
    - This step aims to study the drawbacks of digital assistants and discover the opportunity for digital assistants' improvement.

3.13.2 Online Survey

An online survey was conducted to gather public opinion about digital assistants. This survey's main aim was to gather first-hand information regarding the usefulness of digital assistants, ease of use, benefits of using digital assistants, and the possible threats incurred by using digital assistants from the public point of view.

The information gathered from this survey helped understand the participants' preference towards using digital assistants. Moreover, the online survey helped in obtaining information that was used to test the hypotheses.

The information obtained from the structured literature review and an online survey was analysed to check this research's hypotheses. The statistical data obtained from the online sources was used to analyse digital assistants' performance in a real-world scenario and predict the future of digital assistants. 62 participants responded to the survey. The analysis of the survey was done based on the responses received from these 62 participants.

3.13.3 Data Collection from Online Sources

The data collection focused on gathering statistics relevant to digital assistants. The main aim of this step was to get quantitative evidence to test the hypotheses. The data was collected from quality sources that include company websites, trustworthy dataset websites, and other Internet sources.

3.14 Data Analysis

The data analysis process aimed to compare the data obtained from various sources. The main aim of analysing the data was to support the hypotheses for this research. The determinants and moderators of the UTAUT model were considered while processing the data.

The statistics obtained from various online sources were processed to support the hypotheses were justified. The statistics were also processed about the information obtained from the literature review.

The data analysis considered the components of the literature review, namely digital assistants' components, applications of digital assistants, and threats possessed by digital assistants as the base for analysing the data. The statistics obtained from the online sources were used to obtain a statistical significance to conclude the research. The responses recorded by the survey were processed to find correlation and patterns between the hypotheses for this research. The output of data analysis is elaborated in the later sections of this report.

4. Analysis

4.1 Analysis of the Literature Review

The data collected by doing the literature review was compared with the hypotheses for this research.

The literature review was conducted in three parts. Each article matched multiple hypotheses for this research. The list of co-relation between the literature review and hypotheses can be found in the literature review table. Based on this correlation, the following conclusion was reached for these hypotheses:

- Users of all ages, genders, and educational backgrounds use digital assistants
- According to public opinion, digital assistants improve work efficiency and are productive
- Many studies and experimentation are being conducted to improve the interaction efficiency and data processing capability of digital assistants
- Digital assistants have a bright future based on the current scenario and undergoing studies
- Data privacy and overdependency are common concerns for users using digital assistants
- Lack of operational knowledge in a user hinders the growth in the demand for digital assistants
- Digital assistants can be vulnerable to cyber attacks
- Digital assistants are used mainly in the medical sector, the aviation sector, the entertainment industry, the corporate sector, and the educational sector.
- Digital assistants embedded with hardware can possess a threat to the human employment
- The possibility of irrelevant responses still prevails in digital assistants
- The demand for digital assistants is increasing.

4.2 Analysis of Data Collected from various Internet Sources

The main aim of collecting data from online sources was to obtain statistical information regarding the trend of digital assistants. The data gathered from the online sources was used to study user preference for using digital assistants, functionalities provided by digital assistants, and predict digital assistants' future in a real-world market scenario.

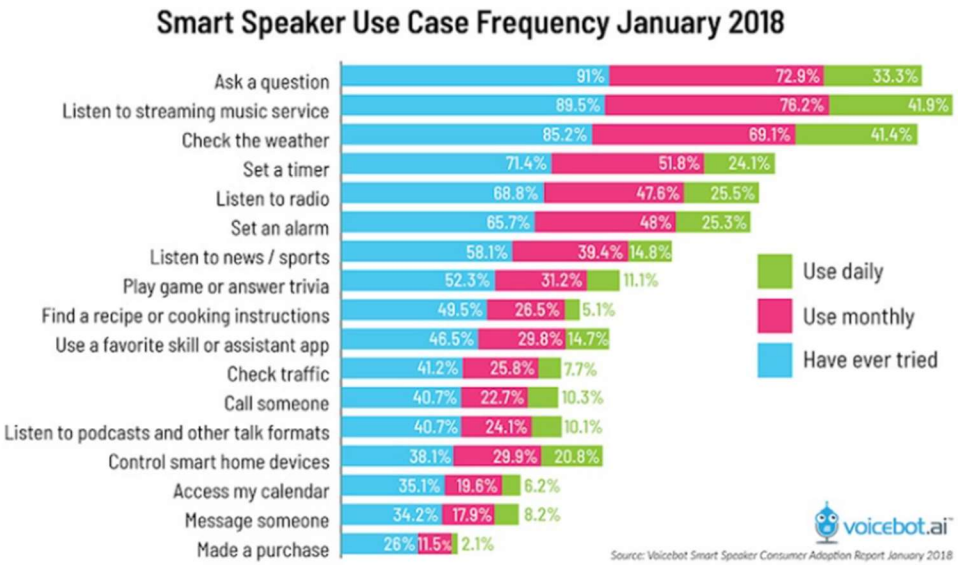

Figure 6: Use case information for digital assistants

("Smart speaker sales, forecasts and market share: amazon echo, google home, apple homepod and more," 2018)

- Figure 6 provides information about the usage frequency of digital assistants for tasks like internet search, weather notifications, and online shopping.
- Figure 6 indicates that people have tried using the functionalities of digital assistants at least once. Hence, it can be interpreted that the users are familiar with the functionalities offered by digital assistants and that the users have operational knowledge of digital assistants.
- Figure 6 also indicates that very few people prefer using digital assistants daily.

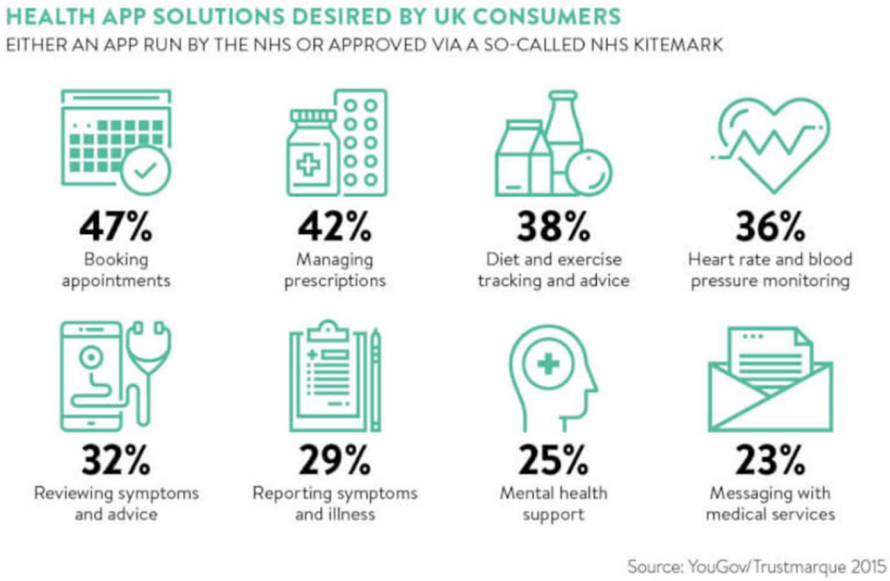

Figure 7: Health assistants data comparison for the UK

("Chatbots will serve as health assistants," 2017)

- Figure 7 provides information about the use of digital assistants in the medical sector.
- Figure 7 indicates that digital assistants are used for tasks like appointment booking, prescription management, health monitoring, information processing, and communication with the patients.
- The medical sector is vital as it relates to the health of the user. Using health assistants indicate trust among the users towards digital assistants
- Hence, it can be derived that the users trust digital assistants for healthcare-related assistance

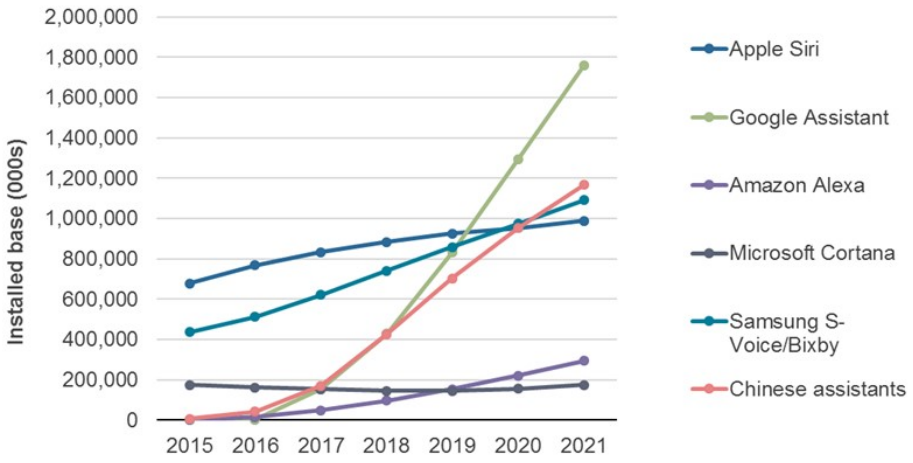

Figure 8: Number of digital assistant applications installed

("More digital assistants than people by 2021, says ovum," 2016)

- Figure 8 shows a comparison of the most commonly used digital assistants based on installations per year
- Based on the information obtained from figure 8, it can be interpreted that the demand for digital assistants is predicted to increase based on the available historical data
- Figure 8 indicates that the popularity of digital assistants is increasing continuously. Hence, it can be interpreted that the demand for digital assistants is increasing and that there is a positive acceptance rate for digital assistants among the users.

Figure 9:User statistics for voice-based assistants

("What is Voice Search Optimization?," 2019)

- Figure 9 shows the statistics of voice searches done by users
- Figure 9 gives information about the usage statistics about digital assistants
- Figure 9 indicates that a majority of voice searches were undertaken to research on other products
- Figure 9 also shows that 42% of participants believe in increasing the use of digital assistants
- Figure 9 indicates that users find digital assistants to be effective
- Figure 9 also indicates that the public prefers using digital assistants occasionally
- Figure 9 also states that the majority of the queries lodged by users will be voice search based. This indicates that the application domain of digital assistants is increasing.

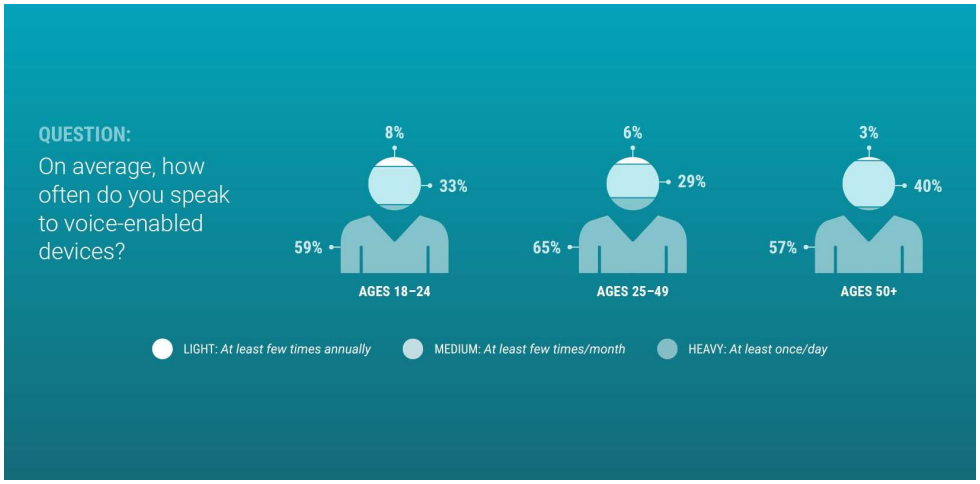

Figure 10:User interaction statistics

(Anderson, 2019)

- Figure 10 shows user interaction statistics concerning digital assistants
- Figure 10 also indicates that users of all age groups interact with digital assistants at least once a day
- Figure 10 also indicates that the users avoid excessive use of digital assistants

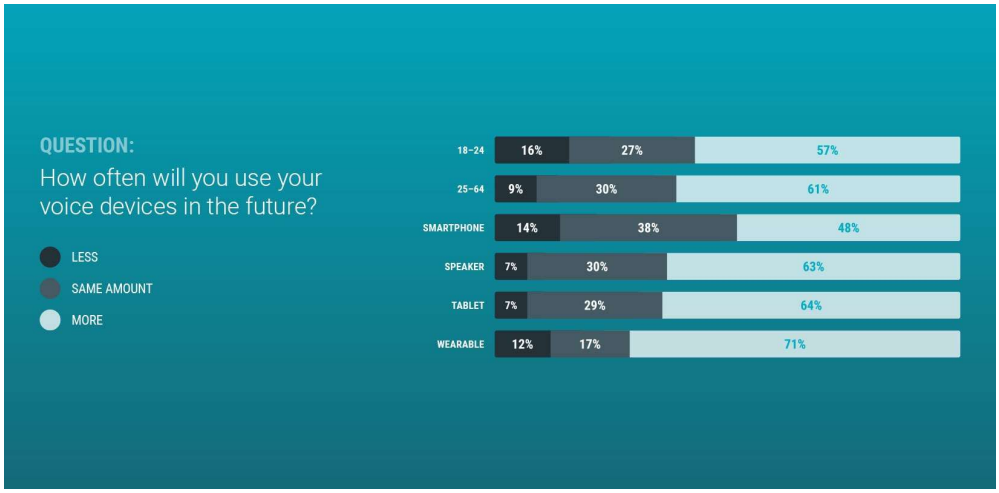

Figure 11: User preferences

(Anderson, 2019)

- Figure 11 displays user preference statistics for digital assistants
- Figure 11 indicates that the majority of users prefer to increase their use of digital assistants in the future
- Figure 11 indicates that the public trusts digital assistants
- Figure 11 also indicates that the application domain of digital assistants is increasing based on user demand.

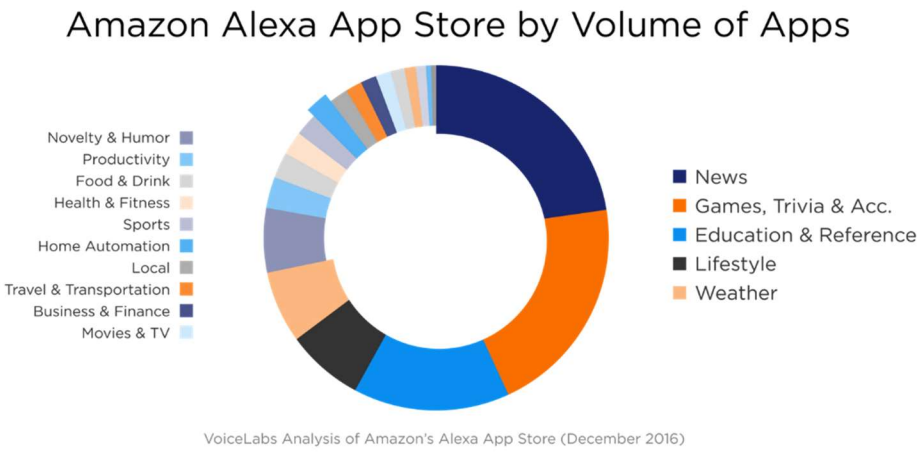

Figure 12: Digital assistant skills list

("Voice assistant industry market statistics," 2020)

- Figure 12 shows the skillset of Amazon Alexa, a voice assistant
- The majority of the skillset includes news, entertainment, and education-related functionalities
- Figure 12 also indicates that digital assistants have multiple integration possibilities based on skillset demand.

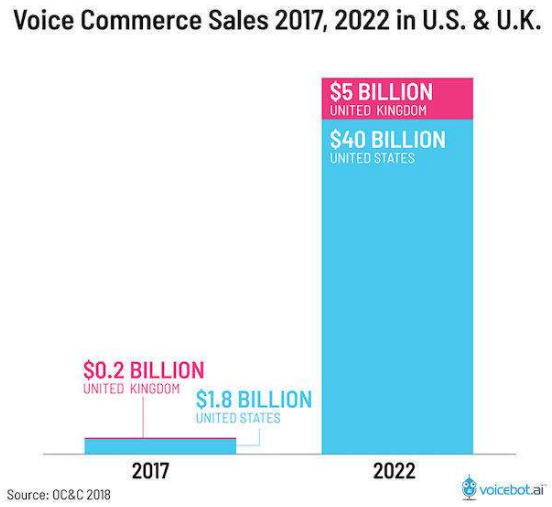

Figure 13: Market prediction for voice assistants

(Donnelly, 2020)

- Figure 13 shows the market prediction for voice assistants
- Figure 13 indicates that the demand for digital assistants will increase in the future based on the infographic
- Figure 13 also indicates that there is an increase in the market demand for digital assistants
- Finally, it can be derived from Figure 13 that the users are satisfied with the use of digital assistants.

4.3 Analysis of the Survey

The survey analysis included studying the responses received by the survey and discovering patterns among the recorded responses. The main aim of analysing the survey was to test the hypotheses based on the received responses. The analysis of the survey can be found below. 62 people participated in the online survey.

Q.1 What is your age group?

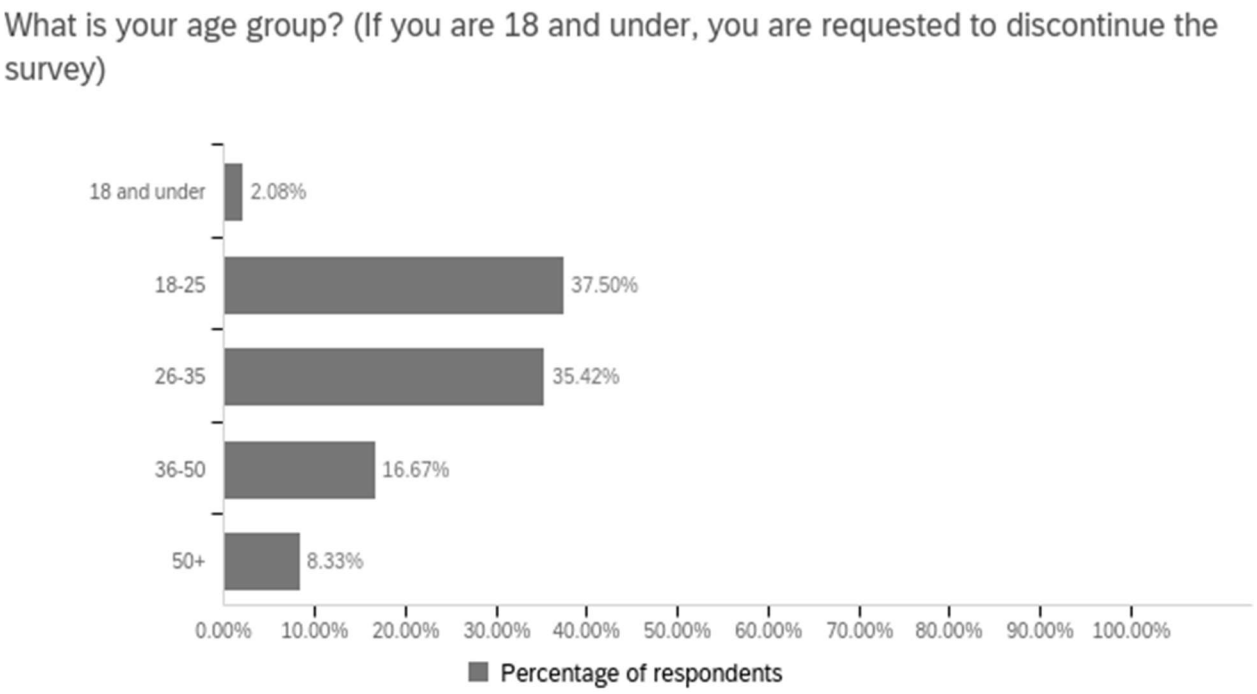

Figure 14: Question for obtaining the age group of the participant

Analysis:

This question was to ensure that the participants are above 18 years of age. This question is important as the age of the participant can provide adequate information about their likeliness of responses. For example, there is a higher possibility of adapting a given technology by students than retired personnel.

The output of this question:

- 37.5% of the participants were in the age group of 18-25, and 35.42% of the participants were in the age group of 26-35
- Maximum participation was received from people between the age range 18-35
- The participants who were under 18 years of age were not allowed to participate in the survey.

Q2. Gender analysis

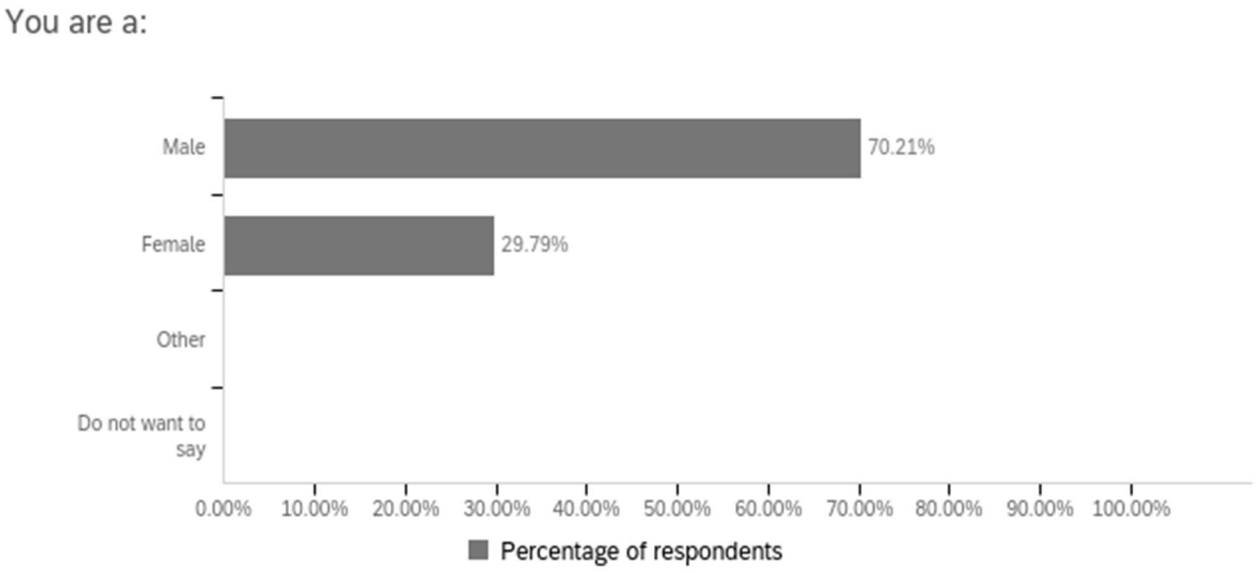

Figure 15: Question to obtain the gender of participants

Analysis:

The main aim of this question is to obtain gender-related information. Gender-related information can be a good filter for analysing the data. This question was included in the survey to analyse the difference between the rate of acceptance of digital assistants for various genders.

The output of this question:

- 70.2% of the participants were males, and 29.79% of the participants were females

- More males answered the survey than females.

Q3. What is your educational background?

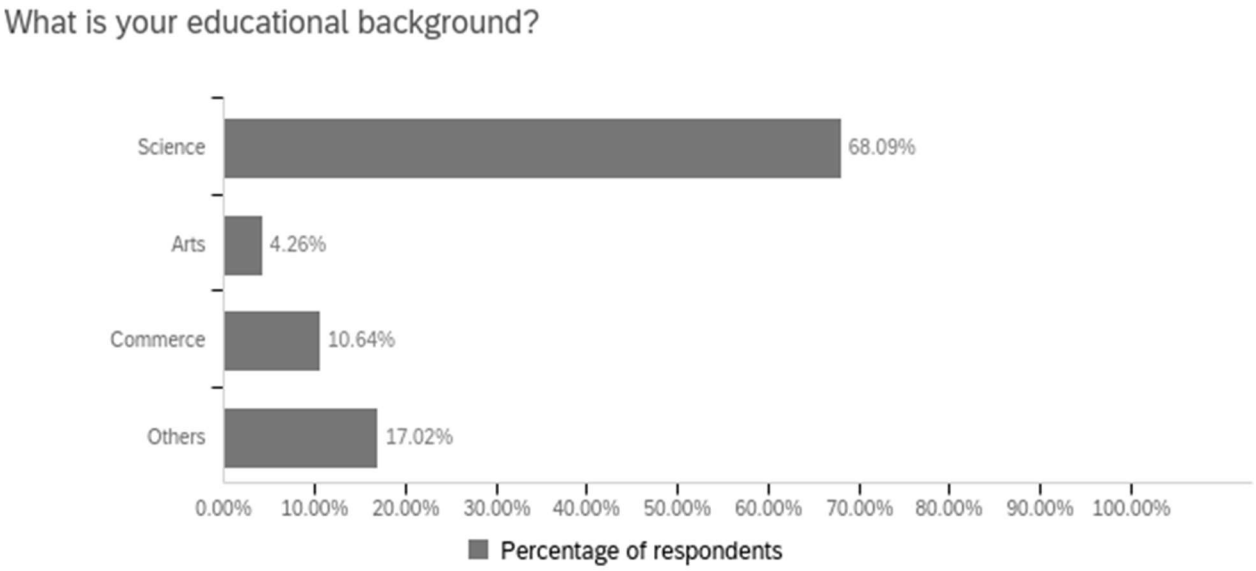

Figure 16: Question for obtaining the educational background of the participant

Analysis:

This question helps in understanding the educational background of the respondent. Based on the educational background, it is possible to assume whether the participant has prior knowledge of digital assistants or not. Getting the educational background also helps in discovering the potential application domains of digital assistants. Moreover, getting educational background can further divide the output of other survey questions to derive a conclusion.

The output of this question:

- 68.09% of participants were from a science background, 10.64% of participants were from a commerce background, and 4.26% of participants were from an arts background
- Maximum responses were recorded from people having a science background
- Figure 16 indicates that the majority of the participants have some knowledge about digital assistants.

- People belonging to other backgrounds provide an opportunity to expand the knowledgebase of digital assistants
- Figure 16 indicates that the participants have interacted with digital assistants at least once.

Q4. Analysis of professional background

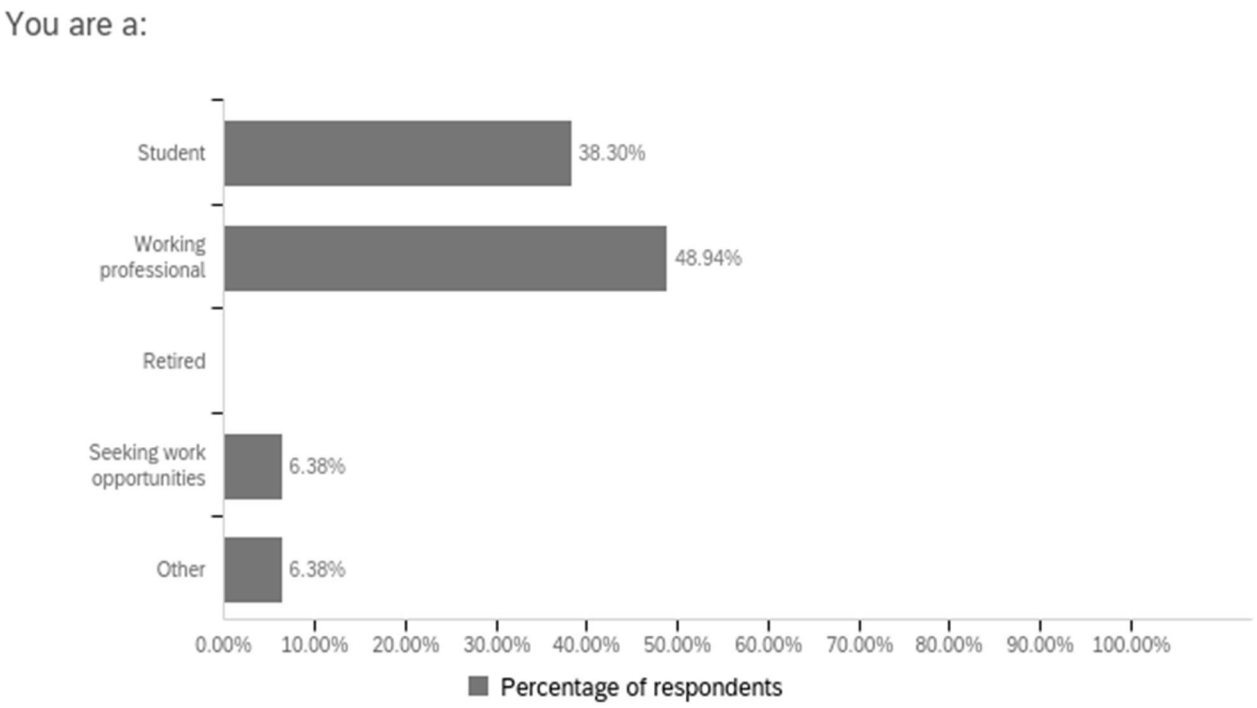

Figure 17: Question to obtain the professional background of the participant

Analysis:

This question aims to obtain information about the professional background of the participants. The obtained data can help in determining the level of interaction of the participant with digital assistants. This question helps to understand the level of acceptance for digital assistants of the respective fields in which participants are engaged.

The output of this question:

- Figure 17 indicates that 48.94% of participants were working professionals and 38.30% of the participants were students
- The majority of participants are working professionals.

Q5. Do you use digital assistants?

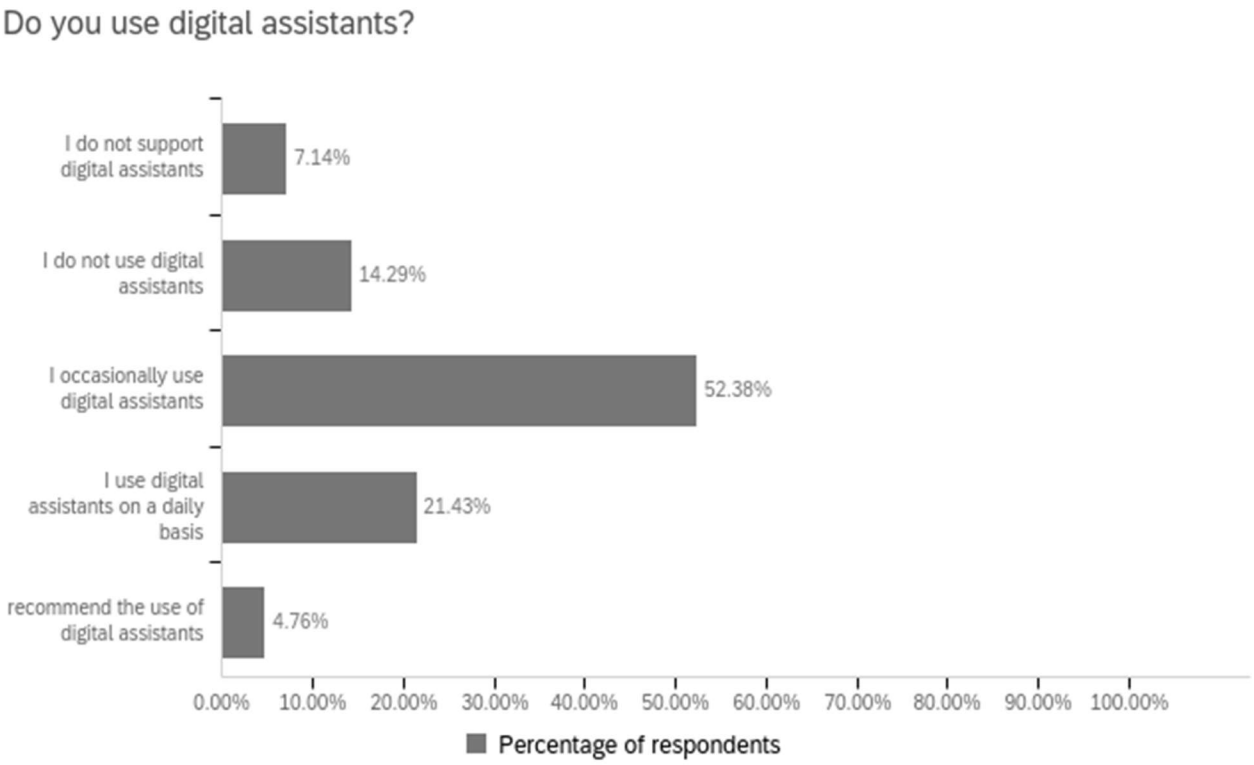

Figure 18: Question to analyse the frequency of use of digital assistants

Analysis:

This is a direct question to know if a participant uses, recommends, or does not recommend a digital assistant. This question can help in understanding the inclination of the participant to use digital assistants.

The output of this question:

- 52.38% of participants use digital assistants occasionally whereas 21.43% of participants use digital assistants daily
- The majority of respondents use digital assistants occasionally
- Very few participants did not support digital assistants
- Participants think that digital assistants are useful to some extent but do not want to be dependent on them

- As compared to participants who do not use digital assistants, more participants use digital assistants either occasionally or daily
- This response shows that the participants support using digital assistants.

Q6. How often do you use digital assistants?

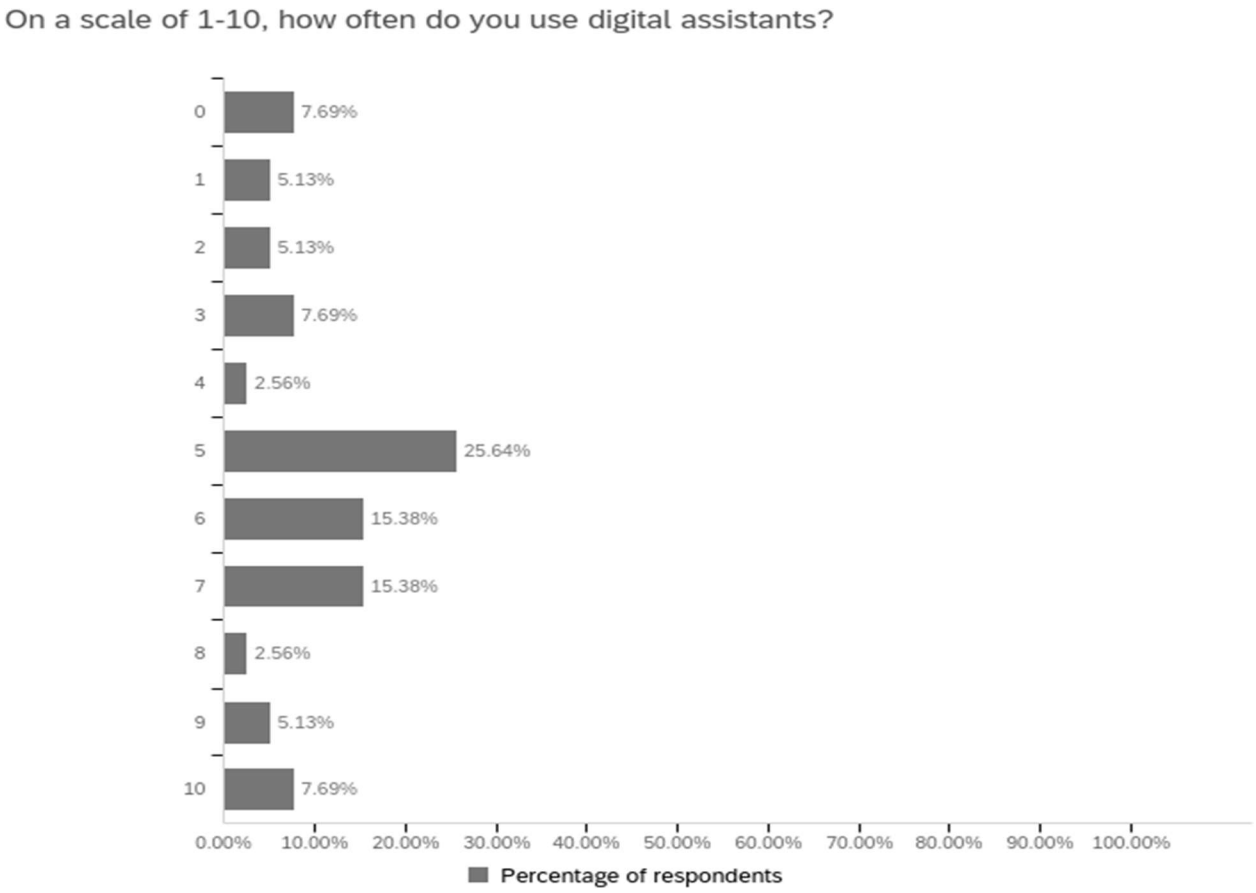

Figure 19: Question to analyse the frequency of use of digital assistants

Analysis:

This question helps to understand the frequency of use of digital assistants. This question is extended from the previous question to get a clear idea about the frequency of use of digital assistants. The numbers 1 to 10 on the vertical axis represent the score selected by the participant.

The output of this question:

- 25.64% of participants voted 5, 15.38% voted 6, and 15.38% voted 7 as their frequency of use of digital assistants
- The diagram given above supports the output of the previous question
- The majority of participants have chosen 5/10 as their frequency for the use of digital assistants
- The image also indicates that users prefer using digital assistants occasionally.

Q7. How useful do you think digital assistants are?

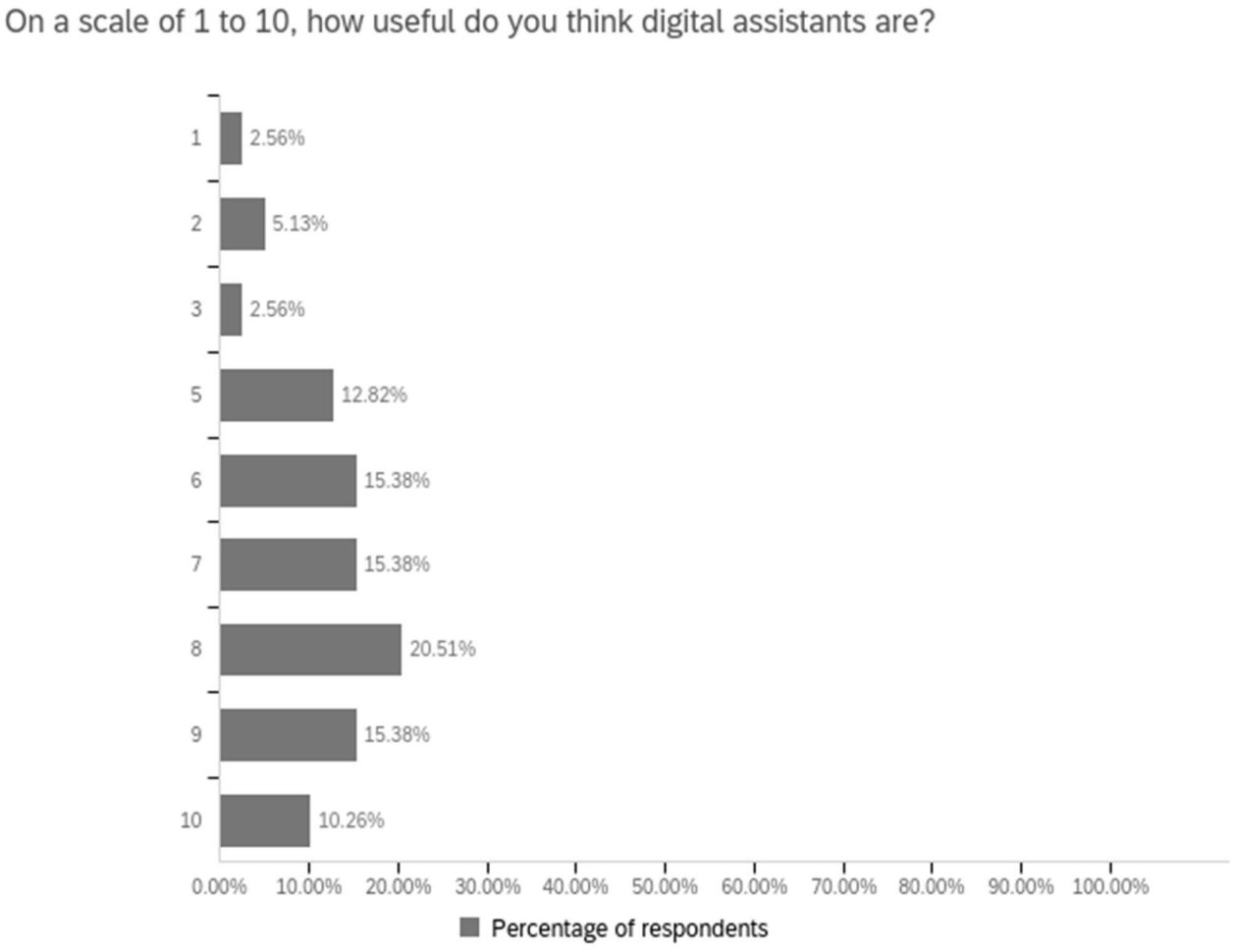

Figure 20: Question regarding the use of digital assistants

Analysis:

This question aims to understand public opinion about the usefulness of digital assistants. This question's output may help determine the probability of support of digital assistants in the market. The numbers 1 to 10 on the vertical axis represent the score selected by the participant.

The output of this question is:

- 20.51% voted 8, 15.38% voted 6, 15.38% voted 7, and 15.38% voted 9 as the usefulness of digital assistants
- More than 50% of participants voted above 5. The received rating indicates that the majority of participants think that digital assistants are useful
- The output shows that participants think that digital assistants are useful in their daily routine
- The output can also be considered to assume that digital assistants have a high acceptance rate in the market.

Q8. How much do digital assistants contribute to improving task efficiency?

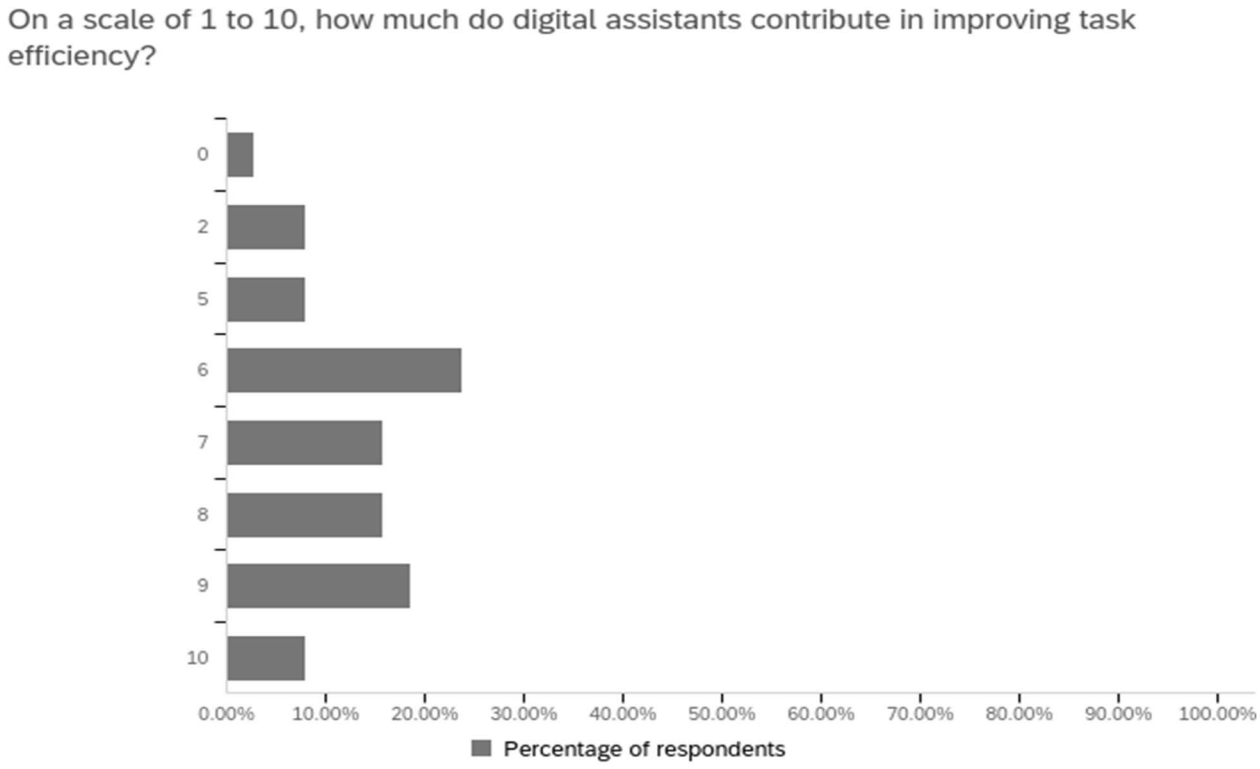

Figure 21: Question regarding the task efficiency of digital assistants

Analysis:

This question aims to record public opinion about the usefulness of digital assistants. This question complements the previous question. The output of this question can be used to determine the success of digital assistants in the market. The numbers 1 to 10 on the vertical axis represent the score selected by the participant.

The output of this question:

- 23.68% voted 6, 15.79% voted 7, 15.79% voted 8, and 18.42% voted 9 for the task efficiency of digital assistants
- More than 50% of participants voted above 6. This rating indicates that participants think that digital assistants are efficient in the functionalities they provide.
- The overall analysis of the output shows that the majority of participants feel that using digital assistants helps in improving task efficiency
- The output also indicates that there are some participants among the participants on the supporting side of digital assistants who feel that digital assistants significantly contribute to increasing task efficiency.

Q9. Digital assistants make our work easy; do you agree?

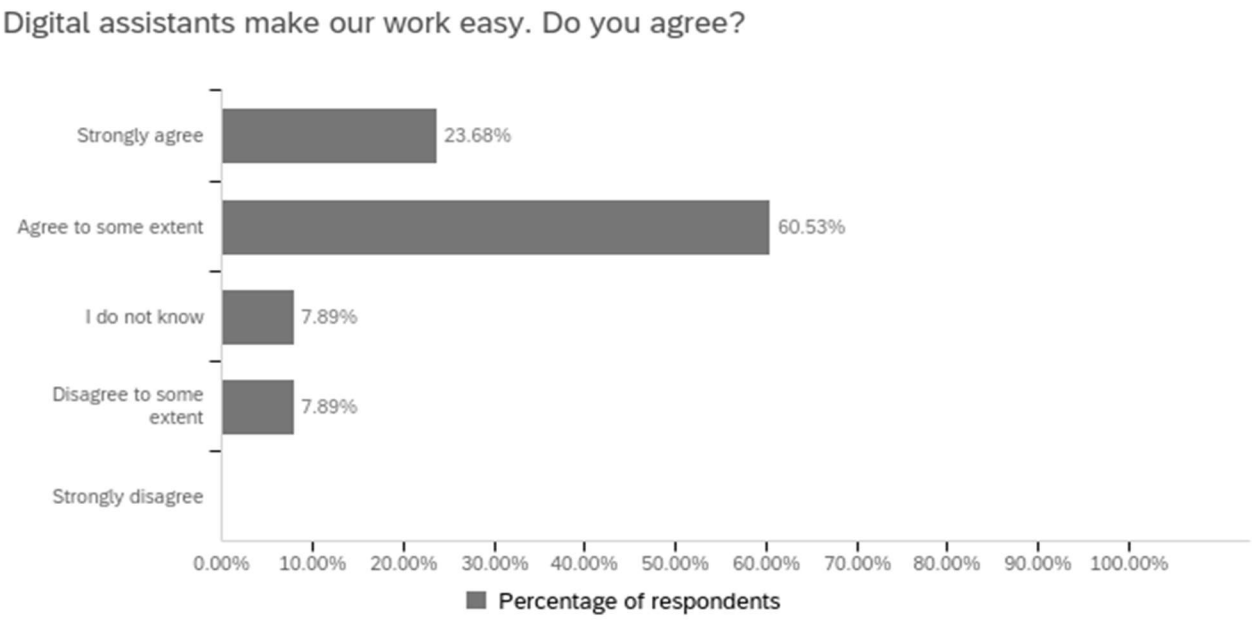

Figure 22: Question regarding the ease of use and productivity of digital assistants

Analysis:

This question aims to gather public opinion regarding the ease of use of digital assistants. If the public feels that it is easy to interact with digital assistants, there is a higher chance of digital assistants having high demand.

The output of this question:

- 60.53% of participants somewhat agree, and 23.68% strongly agree that digital assistants improve task efficiency
- Participants feel that digital assistants make their work easy to some extent
- Some participants strongly believe that digital assistants make work easy
- The diagram indicates that the majority of participants believe that digital assistants make work easy.

Q10. Digital assistants save time and effort, do you agree?

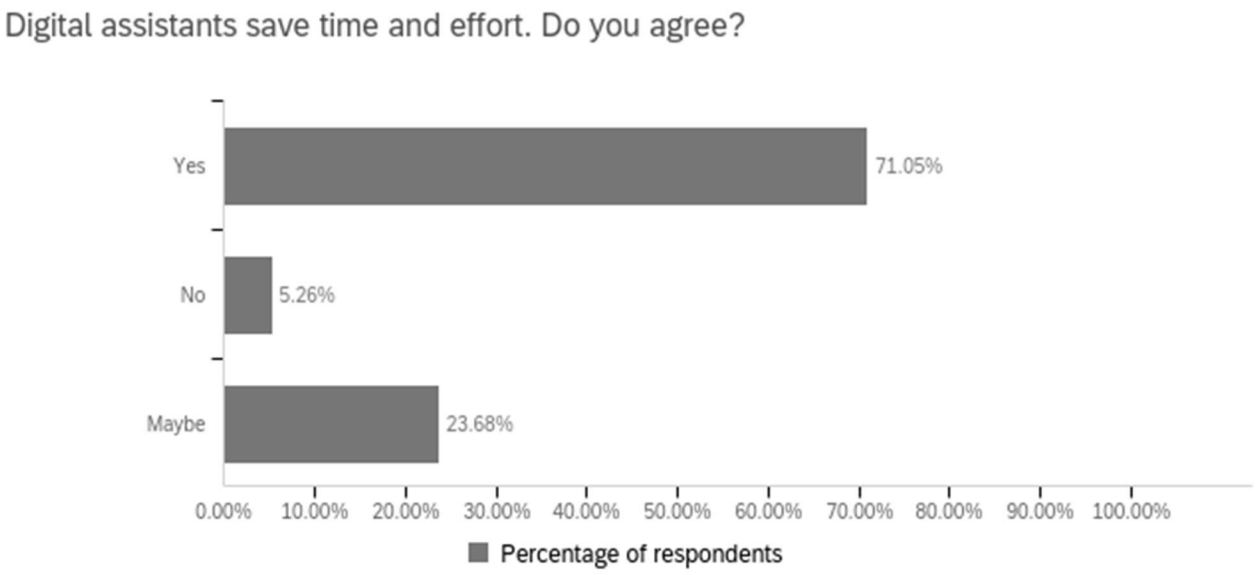

Figure 23: Question regarding the ability of digital assistants to save time and effort

Analysis:

This question aims to obtain the public's opinion regarding the efficiency of digital assistants. Suppose the public agrees that digital assistants save time and effort. In that case, it can be assumed that digital assistants can be productive and can help in easing the work environment.

The output for this question:

- 71.05% of participants feel that digital assistants save time and effort, 23.68% of participants think that digital assistants may save time and effort and 2.63% of participants think that digital assistants do not save time and effort
- The majority of participants feel that digital assistants help in conserving time and efforts
- The output also means that digital assistants can be implemented in work environments and have the capacity of expanding their application domain based on market demand.

Q11. Do you think digital assistants have a bright future?

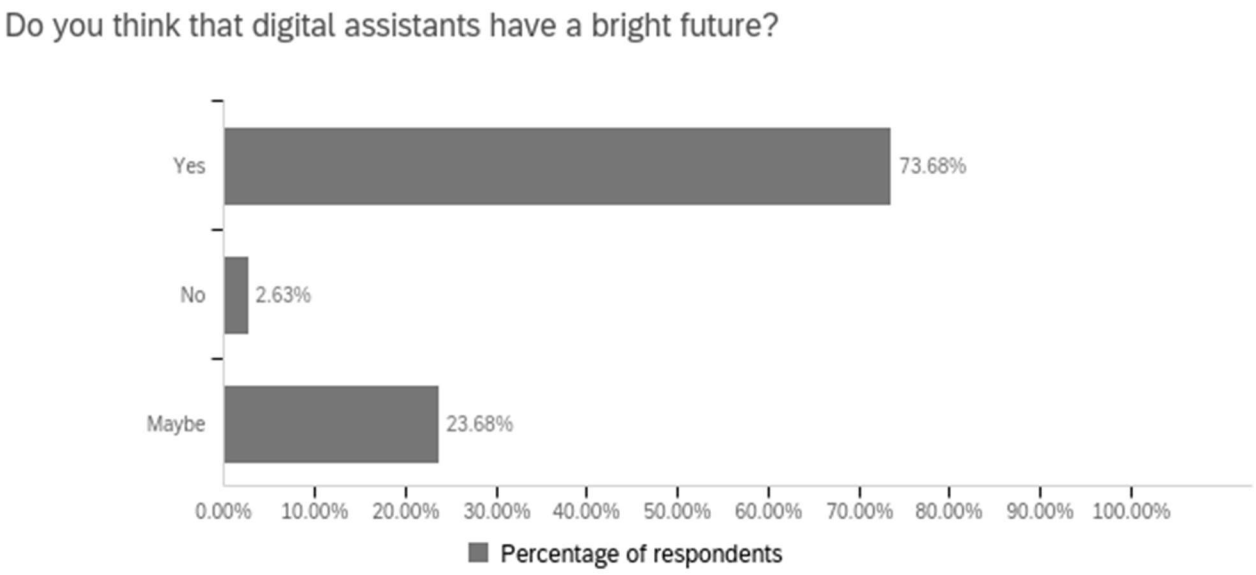

Figure 24: Question to predict the future of digital assistants

Analysis:

The main aim of this question is to analyse if the public thinks that digital assistants will be able to be sustained in the future. This question also helps in understanding if digital assistants can expand their application domains.

The output of this question:

The majority of the participants believe that digital assistants will be able to be sustained in the future:

- 73.68% of participants feel that digital assistants have a bright future, 23.68% of participants think that digital assistants may have a bright future, and 2.63% of participants think that digital assistants do not have a bright future
- This also means that the participants have a sense of trust in the functionality and productivity of digital assistants
- The output of this question also indicates that digital assistants have a high probability of acceptance in the market.

Q12. Would you like to see digital assistants implemented in places like airports, railway stations, banks, and other public places?

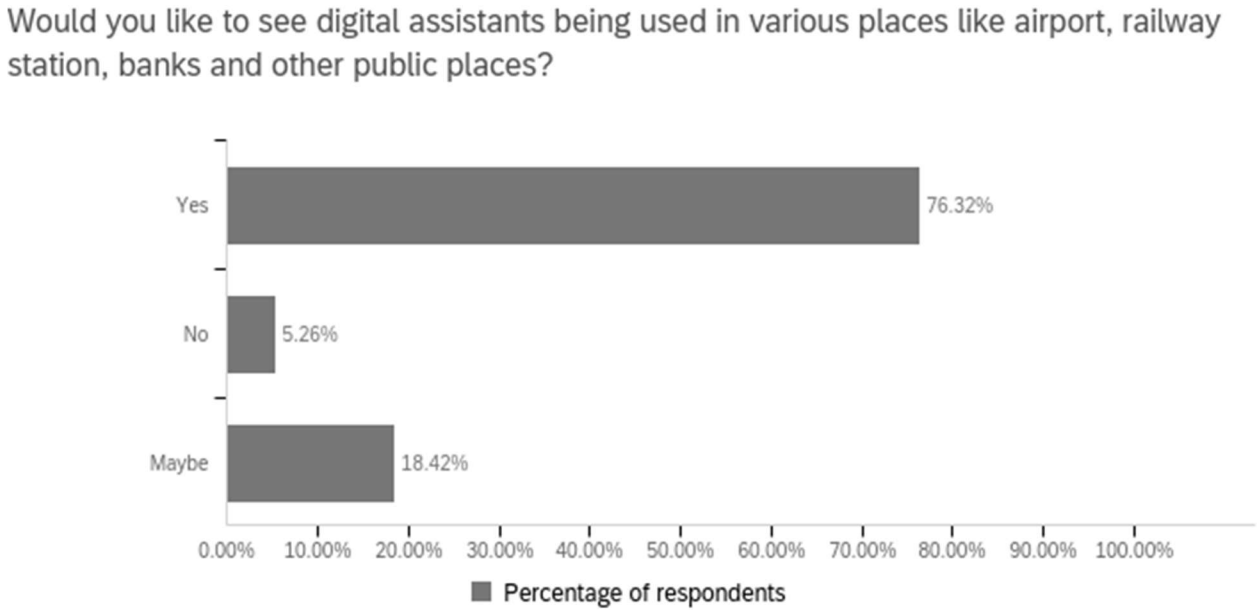

Figure 25: Question to check if participants would prefer increasing their use of digital assistants

Analysis:

The main aim of this question is to predict the degree of acceptance of digital assistants. Public places were chosen for this question because they are amongst the busiest areas. If the participants have positive feedback for this question, this may mean that digital assistants are simple, scalable and that the users find them useful.

The output of this question:

- 76.32% of participants feel that digital assistants should be used more in public places, 18.42% of participants may want digital assistants to be implemented in public places whereas 5.26% of participants feel that they do not wish to digital assistants to be implemented in public places
- The majority of participants would like to see digital assistants implemented in public places

- The output of this question indicates that the public is willing to accept digital assistants in their daily life.

Q13. How effectively can digital assistants contribute towards helping people with disabilities?

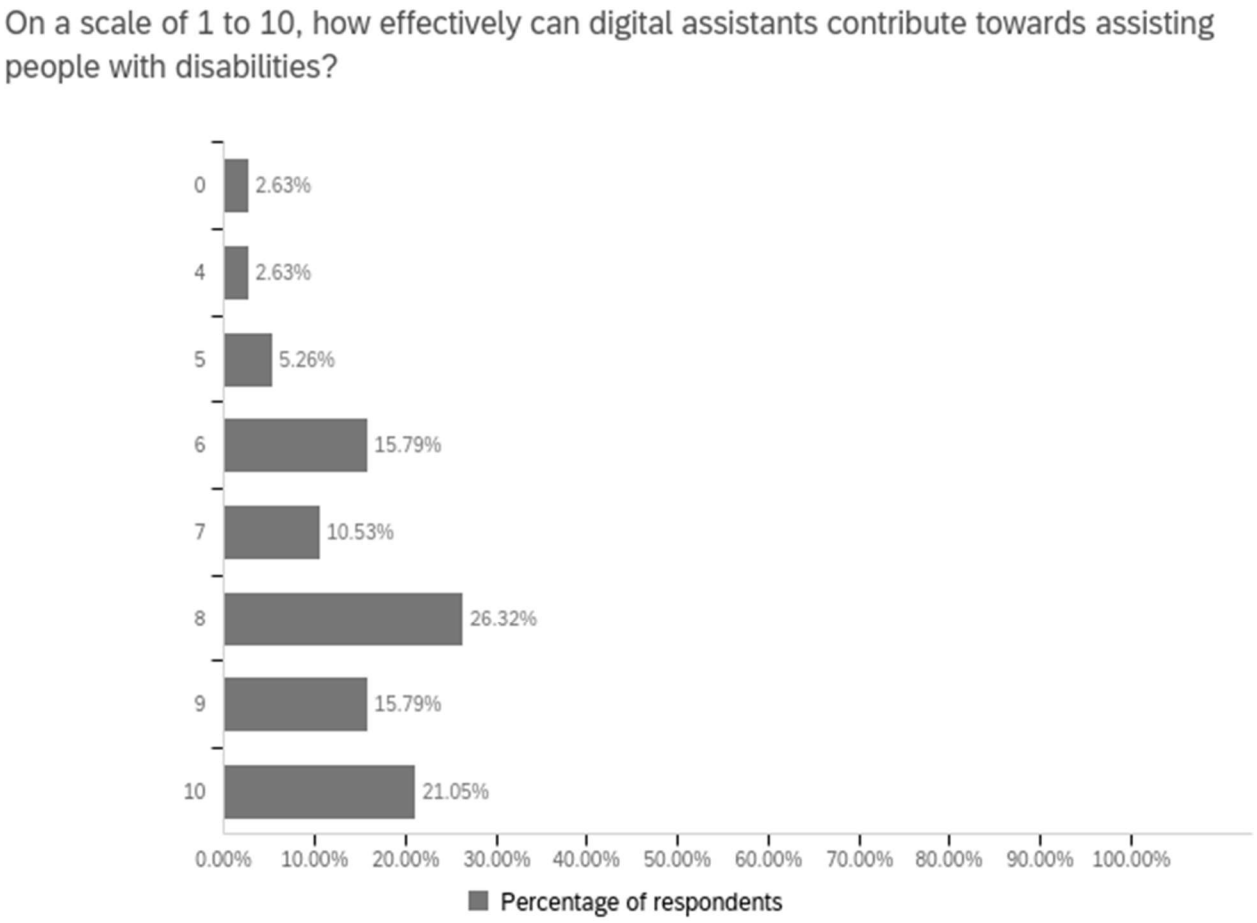

Figure 26: Question regarding the use of digital assistants to assist disabled people

Analysis:

This question was framed to check if participants find digital assistants fit enough to help people having disabilities. This question is vital for this research because based on the responses, there is scope for the implementation of digital assistants to assist disabled people in becoming independent. The numbers 1 to 10 on the vertical axis represent the score selected by the participant.

The output to this question:

- 26.32% of participants voted 8, 21.05% voted 10, and 15.79% of participants voted 9 for digital assistants being able to assist people with disabilities

- More than 50% of participants voted above 7. This rating indicates that the participants believe that digital assistants can help people with disabilities. This rating also indicates that the participants would prefer digital assistants for assisting people with disabilities
- The rating for this question indicates that digital assistants can be implemented to assist people having disabilities
- The response to this question also indicates that people trust digital assistants

Q14. How effectively can digital assistants help in conserving resources?

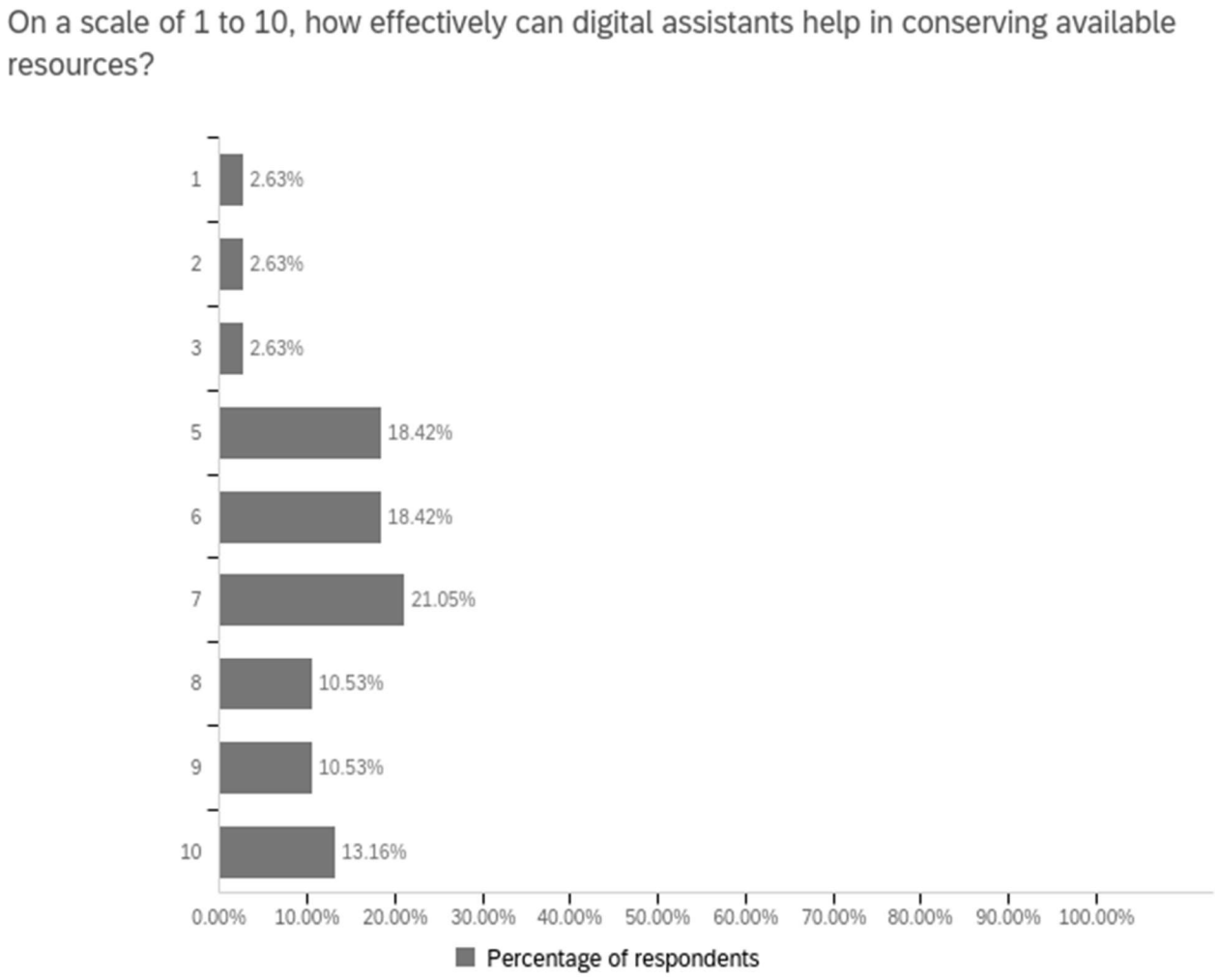

Figure 27: Question regarding the use of digital assistants to save energy

Analysis:

The main aim of this question is to understand the preference of people for using digital assistants. Digital assistants contain several components that can help a user in decision making. The answer to this question can help in determining the readiness of the public to accept the decision support functionalities of digital assistants. The numbers 1 to 10 on the vertical axis represent the score selected by the participant.

The output to this question:

- 18.42% of participants voted 5, 18.42% of participants voted 6, and 21.05% of participants voted 7 for digital assistants being able to assist in conserving available resources
- More than 50% of participants voted above 4. This rating indicates that the participants believe that digital assistants can help in conserving the available resources. This rating also indicates that digital assistants can assist in properly utilizing the available resources
- Figure 27 indicates that participants support the idea that digital assistants can help in conserving available resources.

Q15. What makes you think twice before using a digital assistant?

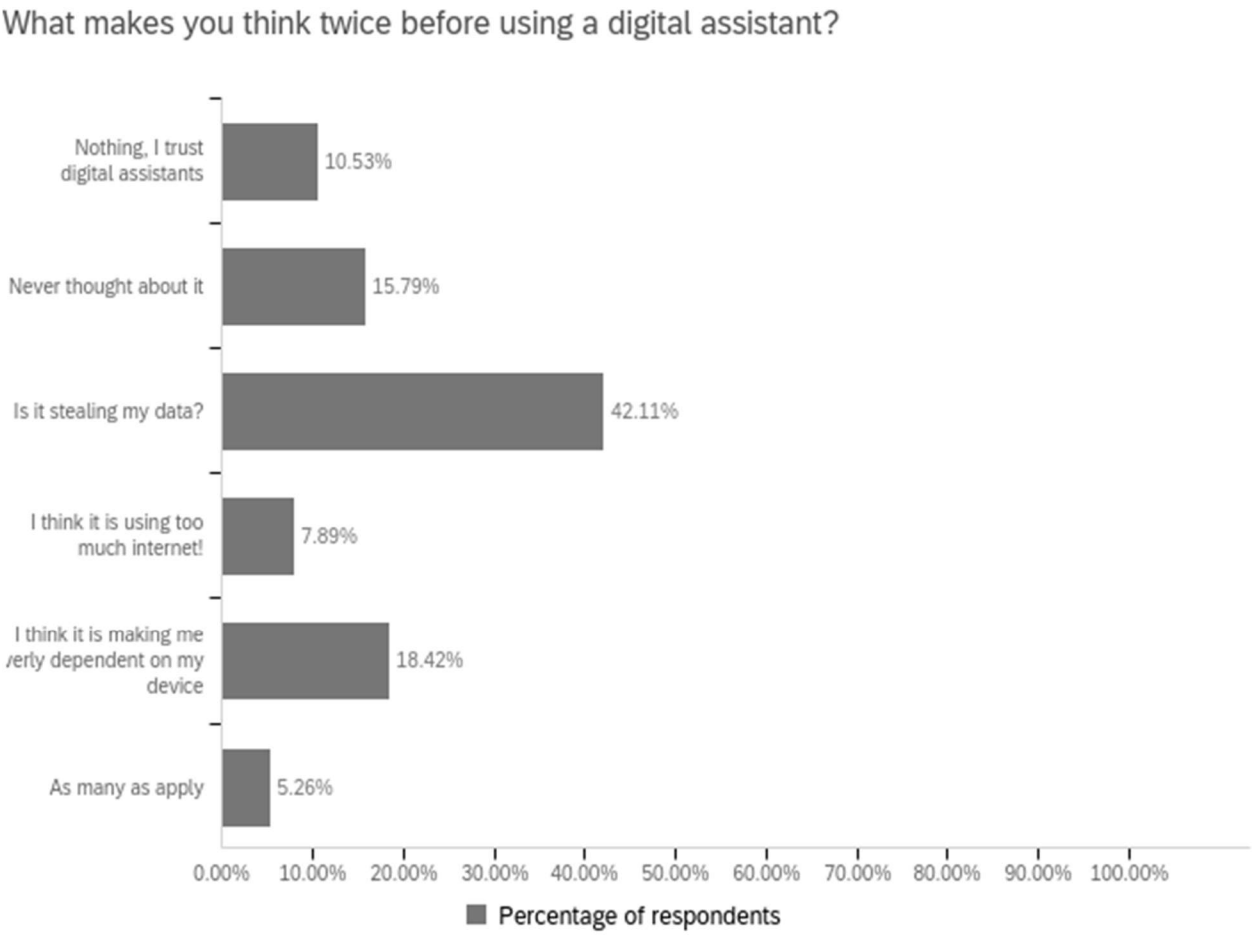

Figure 28: Question to determine the possible threat posed by digital assistants

Analysis:

The question given above and the next question are focused on obtaining a public opinion regarding what could go wrong while using digital assistants. This question is important as it helps in determining the possible challenges of using digital assistants.

The output of this question:

- 42.11% of participants think that digital assistants steal their data, 18.42% of participants feel that digital assistants make users overly dependent on technology and 15.79% of participants have never thought about the possible issues digital assistants might pose
- The majority of participants believe that digital assistants may be stealing personal data

Q16. What according to you is a major challenge for a digital assistant?

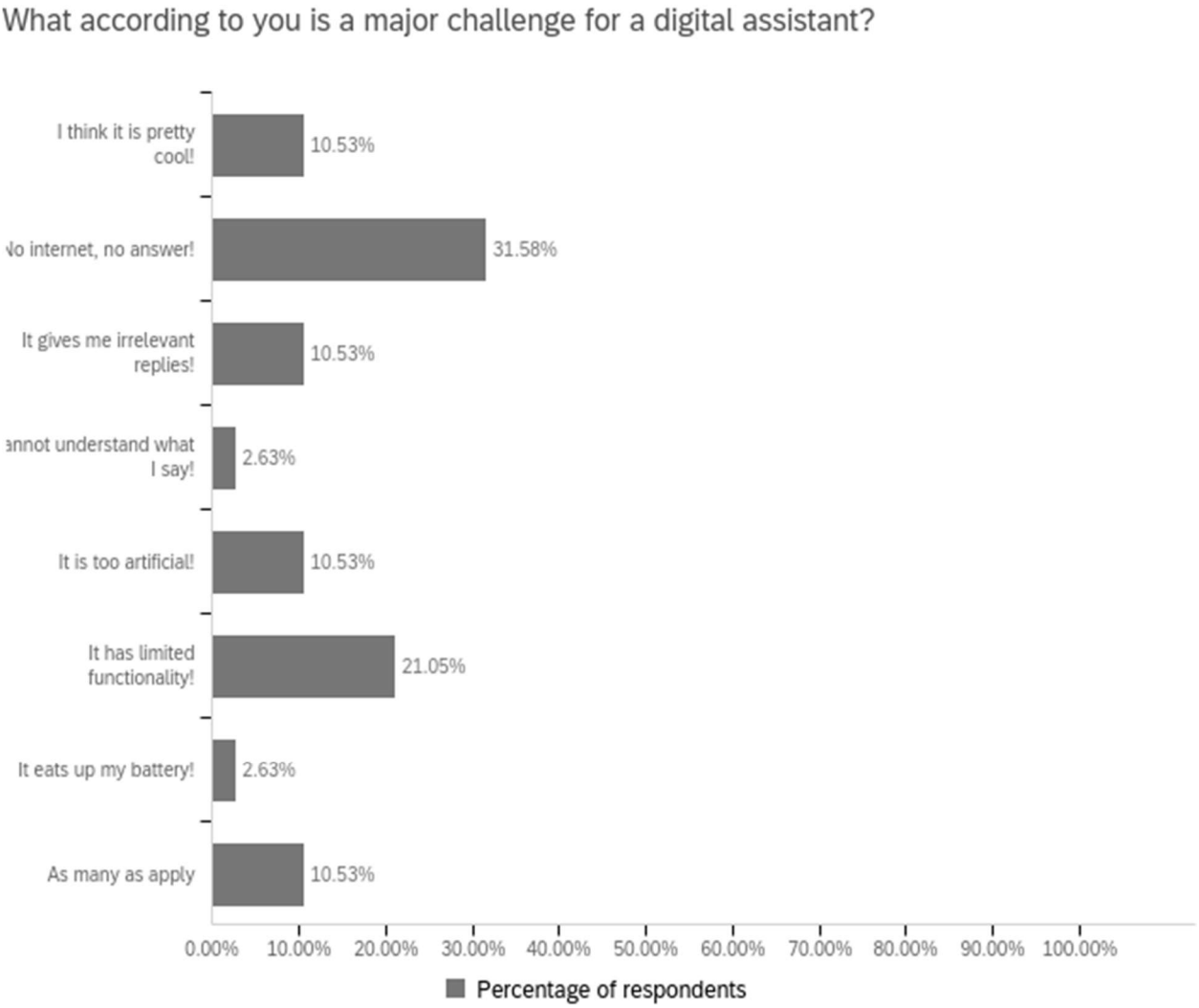

Figure 29: Question regarding the challenges posed by digital assistants

Analysis:

The main aim of this question is to obtain the possible drawbacks of digital assistants from the public point of view. This question can help in identifying and rectifying the possible weaknesses of digital assistants.

The output of this question:

- 21.05% of participants feel that digital assistants have limited functionality and 31.58% of participants think that digital assistants malfunction without the availability of the Internet
- The majority of participants think that digital assistants are useless without the Internet
- 21.05% of participants think that digital assistants have a limited functionality set
- The response to this question indicates the possibility of research concerning digital assistants.

Q17 Digital assistants turn into a disaster, do you agree?

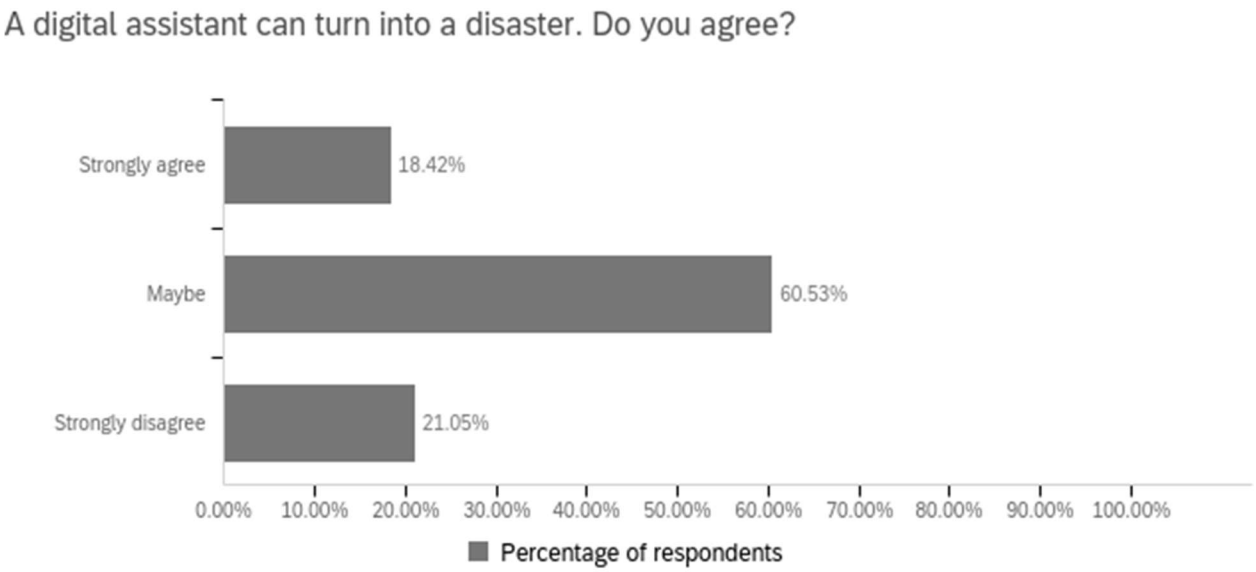

Figure 30: Question regarding the trust of participants in digital assistants

Output:

- 60.53% of participants feel that digital assistants may turn into a disaster, 21.05% of participants strongly disagree that digital assistants may become a disaster and 18.42% of participants think that digital assistants can turn into a disaster

Q18. How do you think that a digital assistant can affect you negatively?

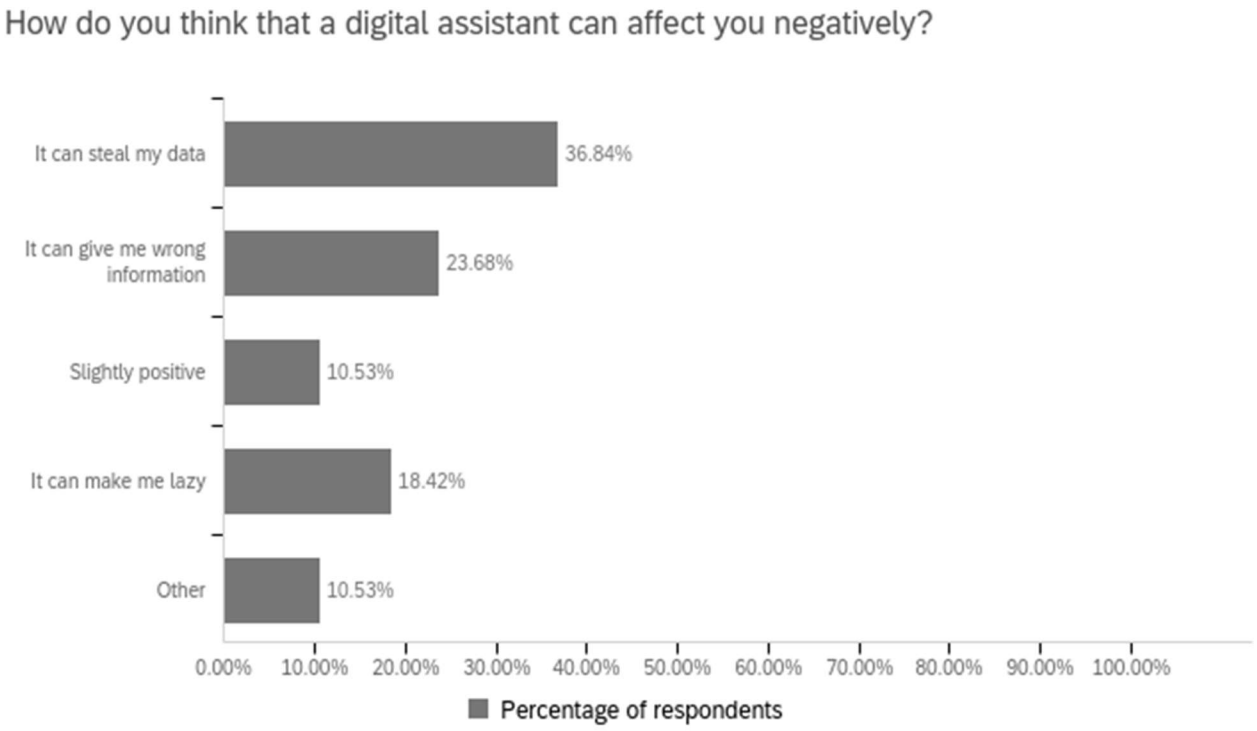

Figure 31: Question regarding the threats posed by digital assistants

Output:

- 36.84% of participants think that digital assistants are stealing their data, 23.68% of participants feel that digital assistants are providing wrong information, and 18.42% of participants think that using digital assistants make users lazy.

Results based on the UTAUT model and subgrouping

The responses collected by the online survey were distributed into subgroups based on the moderators of the UTAUT model like age and gender. The subgroups were analysed to obtain insights from the information collected from the survey. The analysis for the subgroups can be found below:

Analysis based on gender

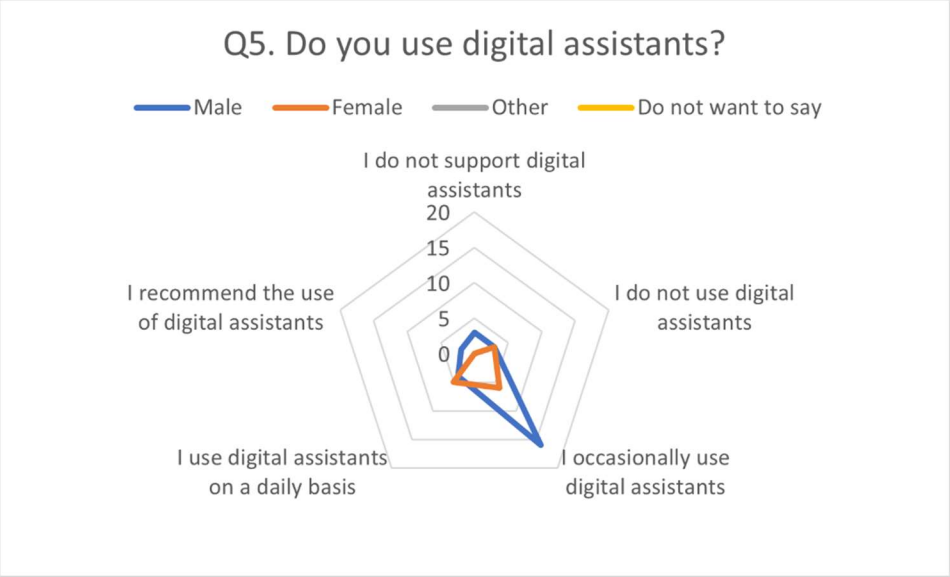

Figure 32: Use of digital assistants based on gender

The numbers 0, 5, 10, 15, and 20 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 32 shows the choices of males and females regarding the use of digital assistants. Figure 32 indicates that more males use digital assistants as compared to females. The blue line represents males, and the orange line represents females. Figure 32 indicates that both males and females prefer to use digital assistants occasionally.

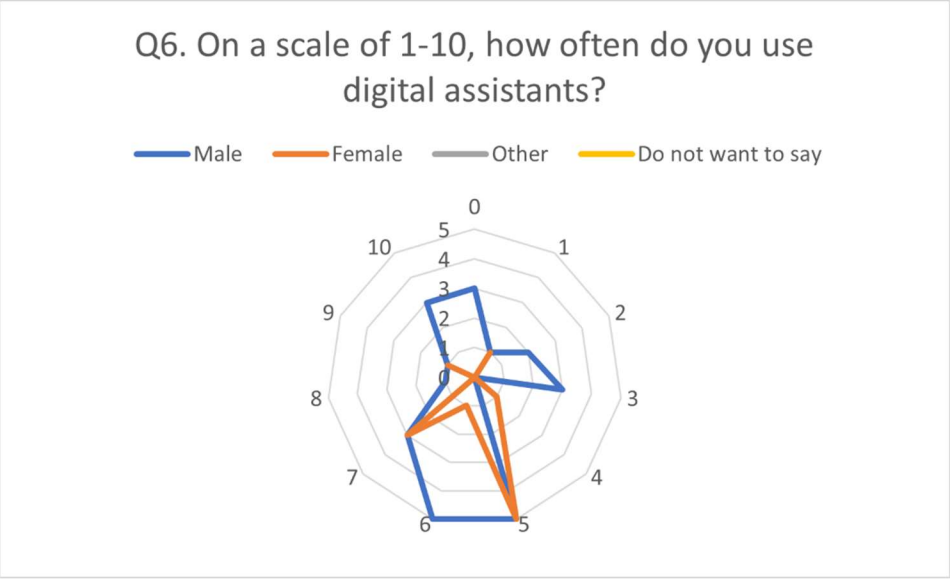

Figure 33: Frequency of use of digital assistants based on gender

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 1, 2, 3, 4, and 5 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 33 shows the frequency of use of digital assistants by males and females. The frequency is determined by the rating selected by males and females from o to 10 on the radar chart. Figure 33 indicates that males and females rated their frequency of use of digital assistants between 5 to 7. Figure 33 complements the information obtained from Figure 32 regarding the use of digital assistants.

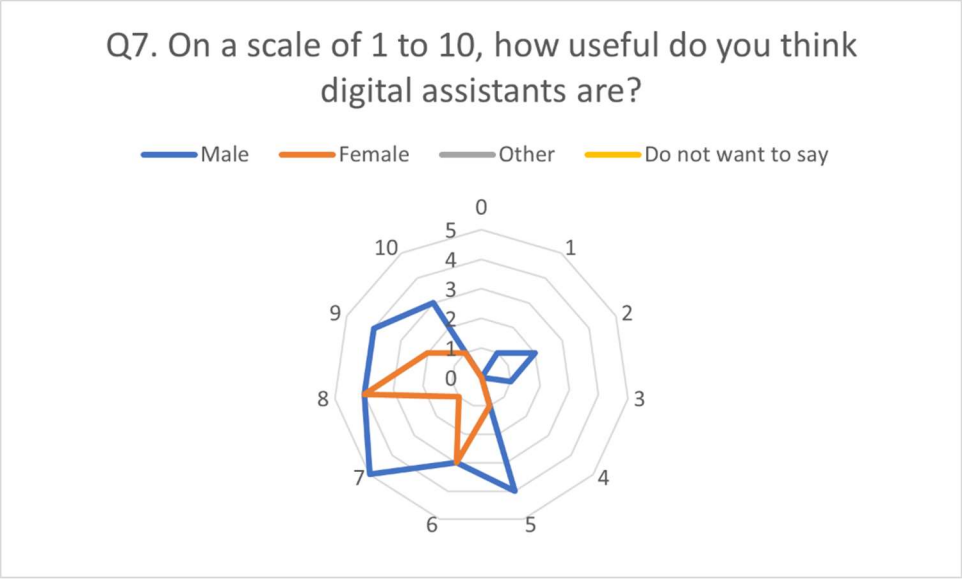

Figure 34: Usefulness of digital assistants based on gender

The numbers 1 to 10 represent the scores selected by the participants. The numbers 0, 1, 2, 3, 4, and 5 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 34 indicates the rating given by males and females regarding the usefulness of digital assistants. Figure 34 indicates that males opted for ratings 5,7 and 9 as the usefulness of digital assistants. Figure 34 also indicates that the females rated the usefulness of digital assistants as 6 and 8.

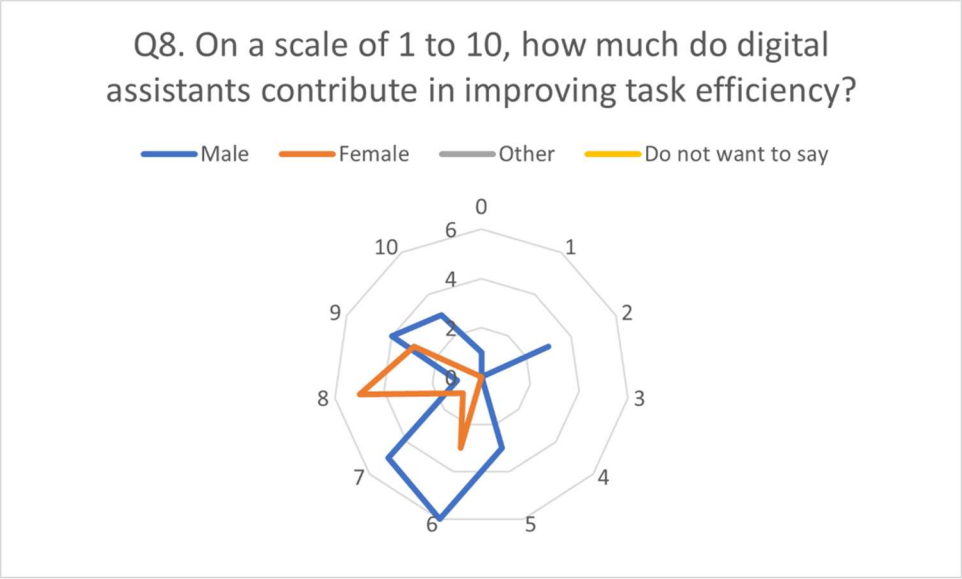

Figure 35: Task efficiency of digital assistants based on gender

The numbers 0, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 35 indicates the ratings given by males and females regarding the task efficiency of digital assistants. Figure 35 indicates that males rated the task efficiency of digital assistants as 2,6, and 9, whereas females rated the task efficiency of digital assistants as 6 and 8. Figure 35 indicates that both males and females think that digital assistants are task efficient.

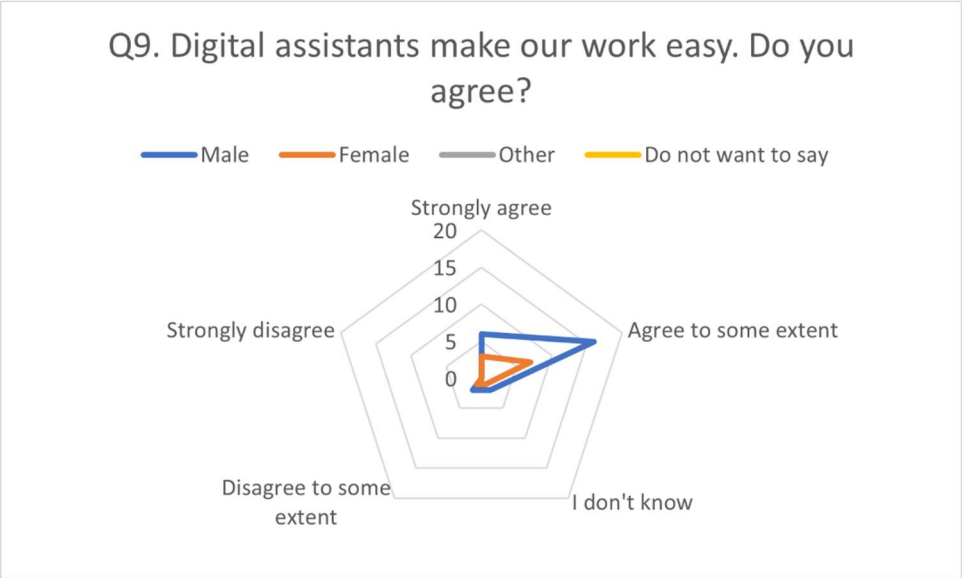

Figure 36: Gender-based opinion about digital assistants making work easy

The numbers 0, 5, 10, 15, and 20 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 36 indicates the opinion of males and females regarding the ability of digital assistants to make work easy. Both males and females agree to some extent that digital assistants make work easy.

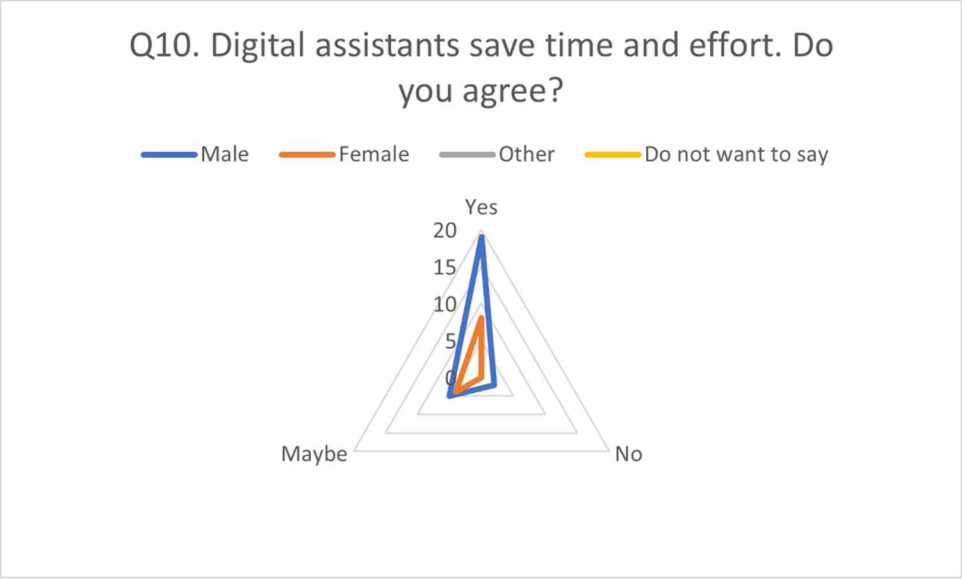

Figure 37: Gender-based opinion about digital assistants saving time and effort

The numbers 0, 5, 10, 15, and 20 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 37 shows males' and females' opinion about the ability of digital assistants to save time and effort. Figure 37 indicates that both males and females agree that digital assistants save time and effort.

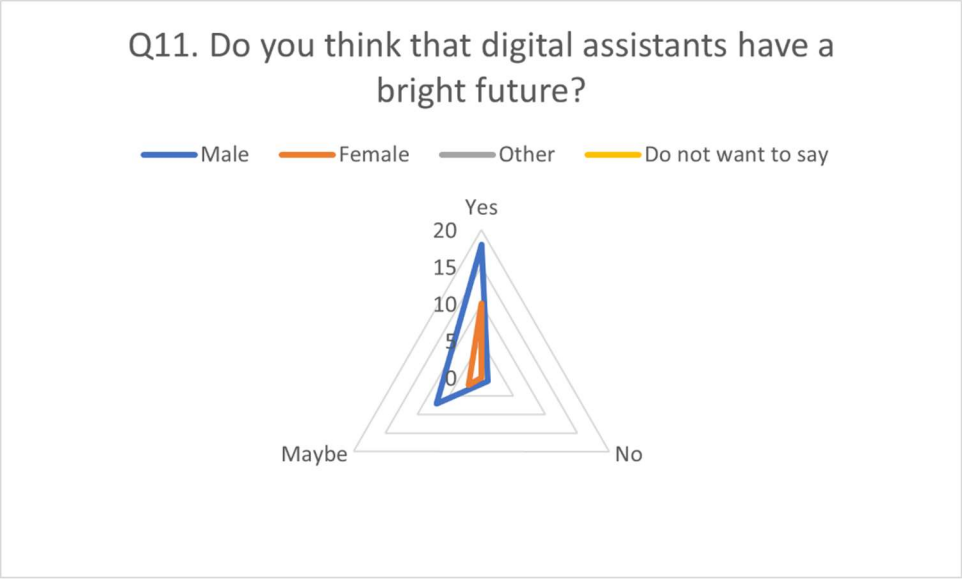

Figure 38: Gender-based opinion about the future of digital assistants

The numbers 0, 5, 10, 15, and 20 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 38 shows the opinion of males and females about the future of digital assistants. Figure 38 indicates that both males and females think that digital assistants have a bright future. Figure 38 also indicates that some males and females are not sure about the future of digital assistants as they answered “maybe”.

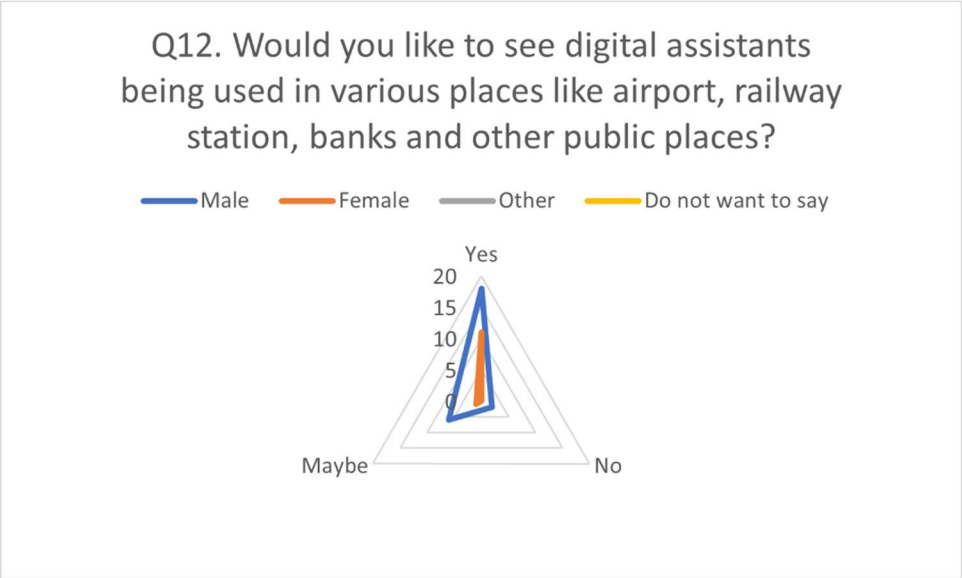

Figure 39: Gender-based opinion regarding the implementation of digital assistants in public places

The numbers 0, 5, 10, 15, and 20 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 39 shows the opinions of males and females regarding the implementation of digital assistants in public places. Figure 39 indicates that both males and females would like to see digital assistants being implemented at public places as they answered “yes”.

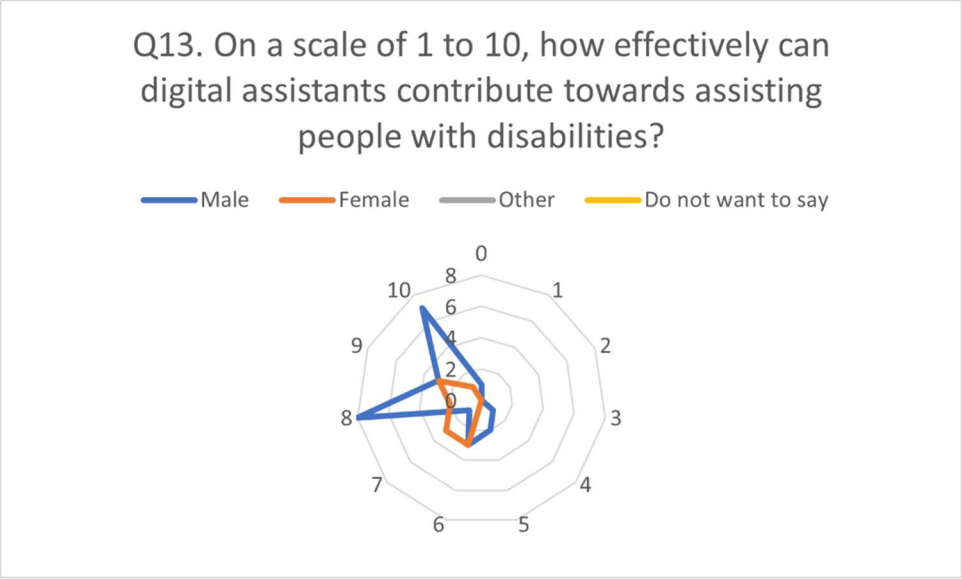

Figure 40: Gender-based opinion regarding the ability of digital assistants to help people with disabilities

The numbers 1 to 10 represent the score selected by the participants. The difference in the lines is because of the difference in the number of responses received from various genders. The numbers 0, 2, 4, 6, and 8 represent the count of participants. Figure 40 shows the opinion of males and females regarding the ability of digital assistants to help people with disabilities. Figure 39 indicates that males voted 8 and 10, whereas females voted 7 and 9 regarding the ability of digital assistants to help disabled people. Hence, both males and females think that digital assistants can be useful for people with disabilities.

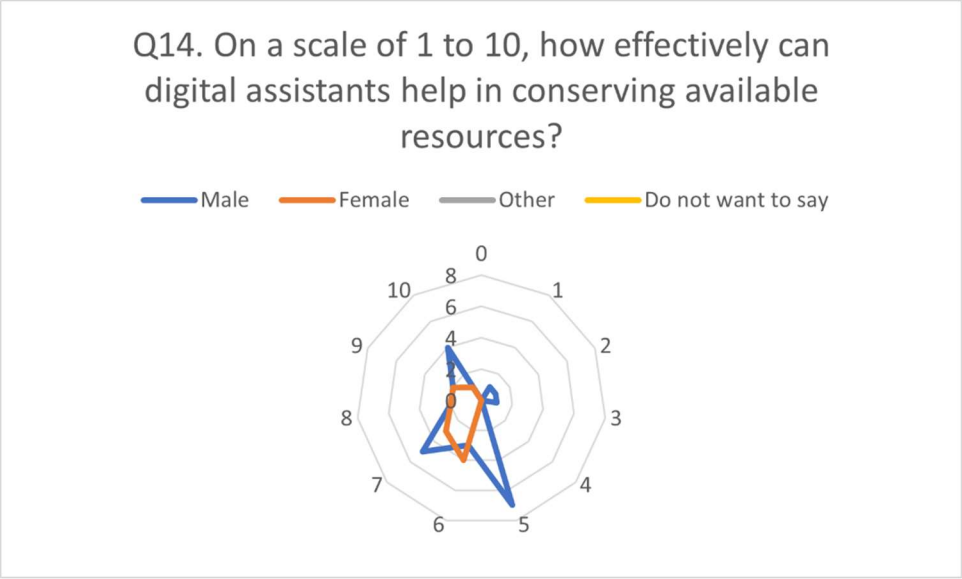

Figure 41: Gender-based opinion about digital assistants being able to assist in conserving available resources

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 41 shows the opinion of males and females regarding the ability of digital assistants to assist the users in conserving available resources. Males voted 5,7 and 10 and whereas females voted 6 as their rating about digital assistants as being helpful in conserving available resources. Hence, Figure 41 indicates that both males and females think that digital assistants can help in conserving resources.

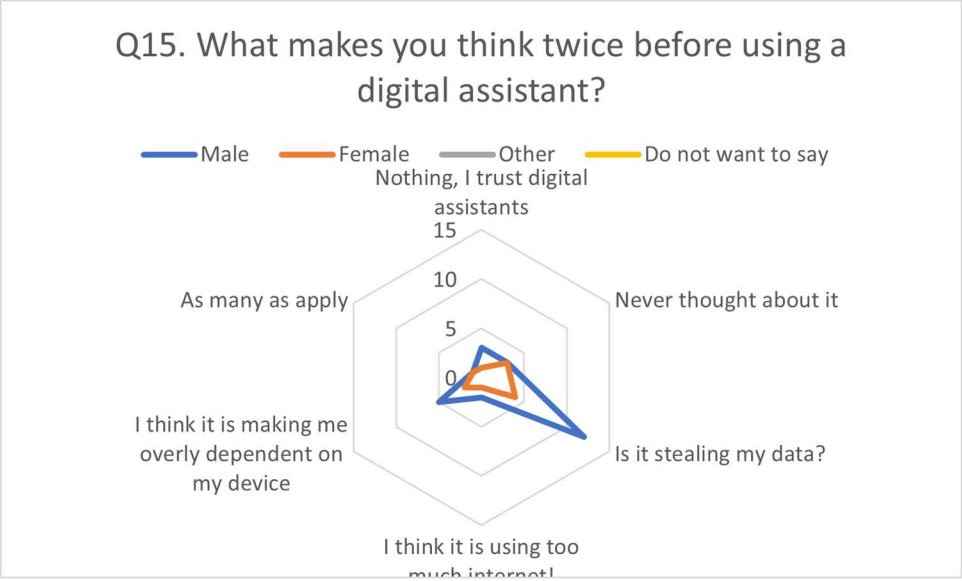

Figure 42: Gender-based opinion about the concerns of using digital assistants

The numbers 0, 5, 10 and 15 on the vertical scale represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 42 shows the opinions of males and females about the concerns of using digital assistants. Males are concerned about data theft and are worried that using digital assistants can make them overly dependent on technology. Females are concerned about data theft. Hence, Figure 42 indicates that both males and females are concerned about their data privacy and confidentiality while using digital assistants.

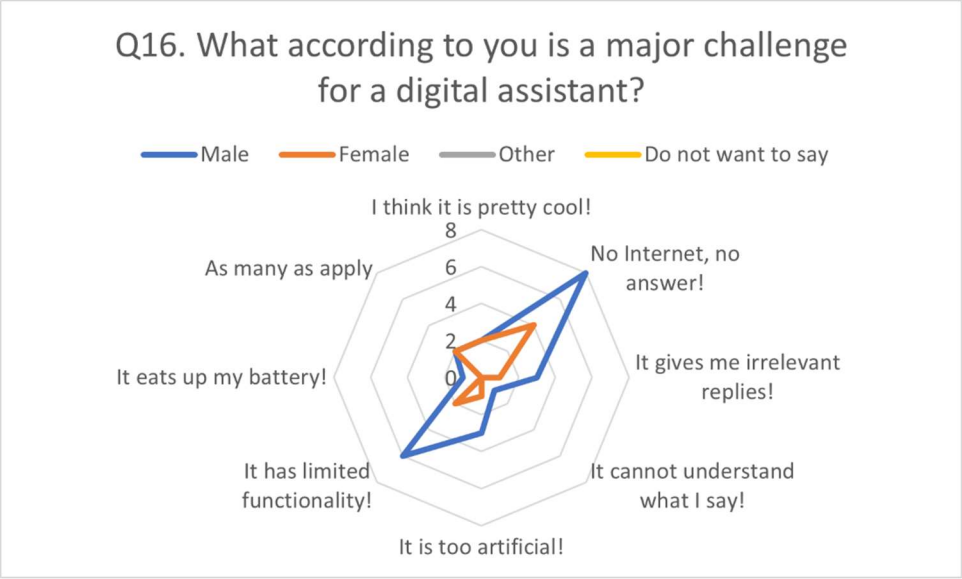

Figure 43: Gender-based opinion about the major challenge of digital assistants

The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 43 shows information about the opinions of males and females regarding the challenges of using digital assistants. Figure 43 indicates that males think that unavailability of the Internet and limited functionalities are challenges of digital assistants. Females think that the unavailability of the Internet and the inability to interpret the user commands are challenges the digital assistants face. Hence, both males and females have unique opinions about the challenges faced by digital assistants.

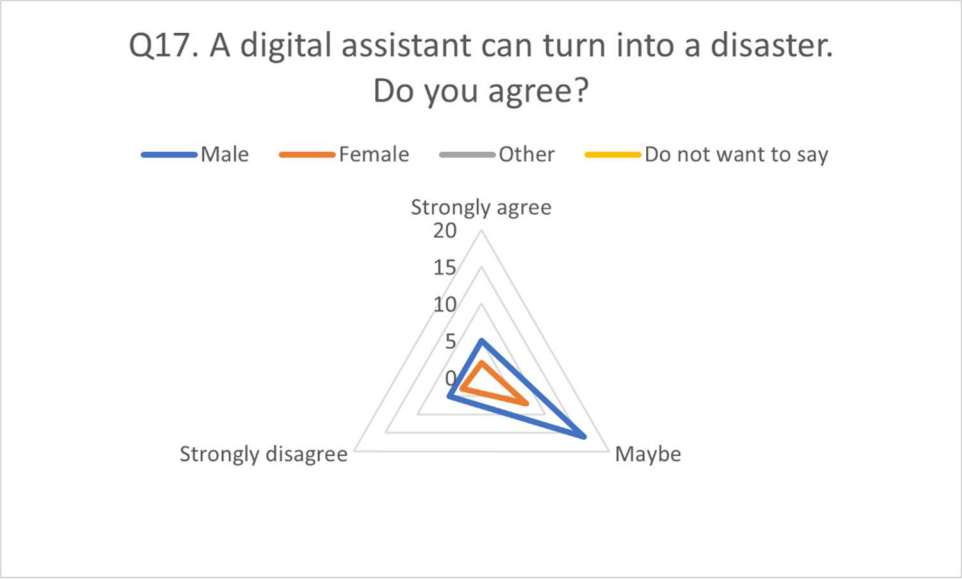

Figure 44: Gender-based opinion about the possibility of digital assistants to turn into a disaster

The numbers 0, 5, 10, 15 and 20 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 44 shows information about the opinion of males and females regarding the possibility of digital assistants turning into a disaster. Males and females think that digital assistants may or may not turn into a disaster as they have chosen the option "Maybe". Hence, both males and females neither agree nor disagree with the possibility of digital assistants turning into a disaster.

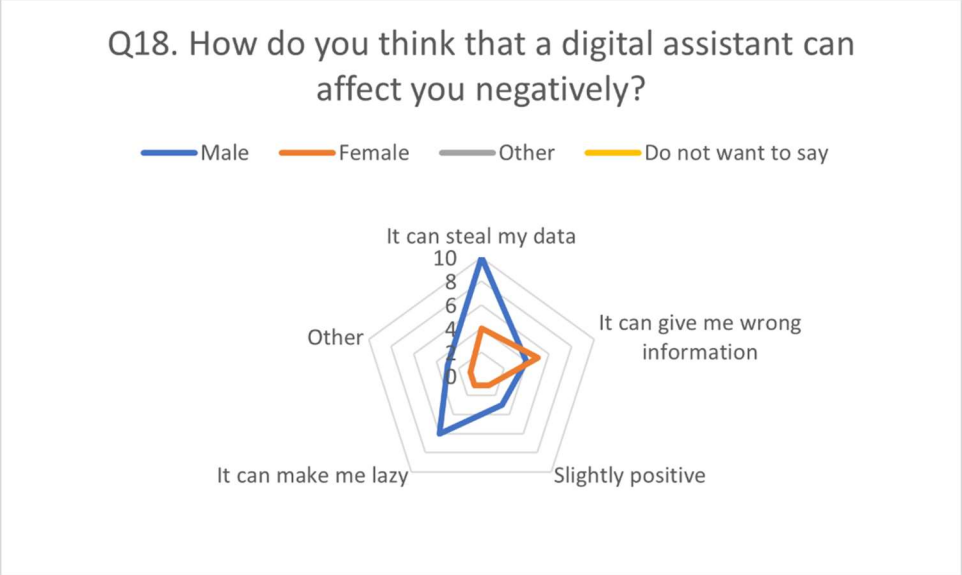

Figure 45: Gender-based opinion about the negative effects of using digital assistants

The numbers 0, 2, 4, 6, 8 and 10 on the vertical scale represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various genders. Figure 45 shows information about the opinion of males and females about the negative effects of using digital assistants. Figure 45 indicates that males think that digital assistants can make them lazy and can steal their data. Females think that digital assistants can provide them with wrong information. Hence, both males and females have their unique opinion about the negative effects of using digital assistants.

Analysis based on Age:

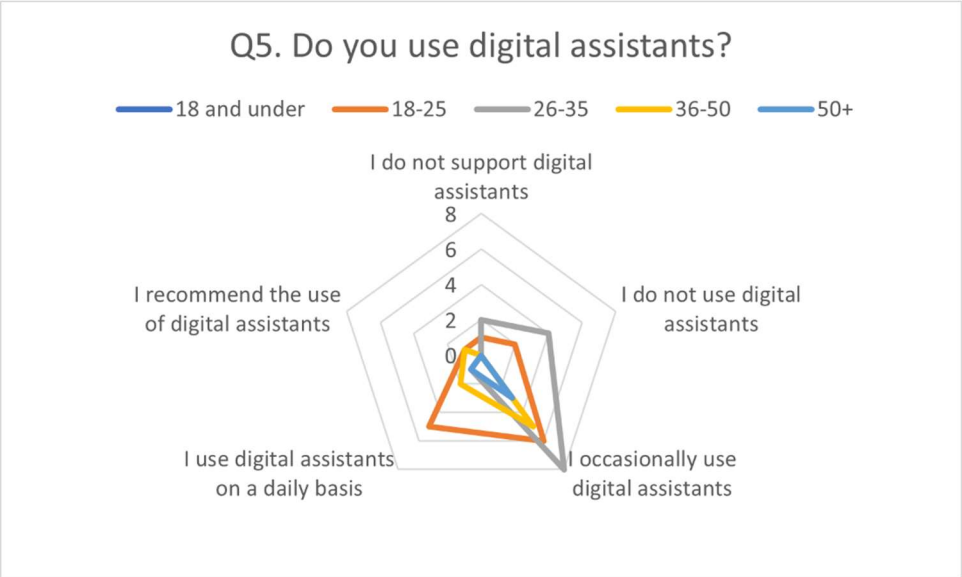

Figure 46: Use of digital assistants based on age group

The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 46 shows information about the use of digital assistants by different age groups. The dark blue line indicates age group of 18 and under, the orange line indicates the age group of 18-25, the grey line indicates the age group of 26-35, the yellow line indicates the age group of 36-50, and the light blue line indicates the age group of 50+. All the age groups voted that they use digital assistants occasionally. People belonging to the age group 26-35 and 18-25 voted that they do not use digital assistants, whereas some users from the same age group use digital assistants

daily. Hence, Figure 46 indicates that users from all age groups prefer to use digital assistants occasionally.

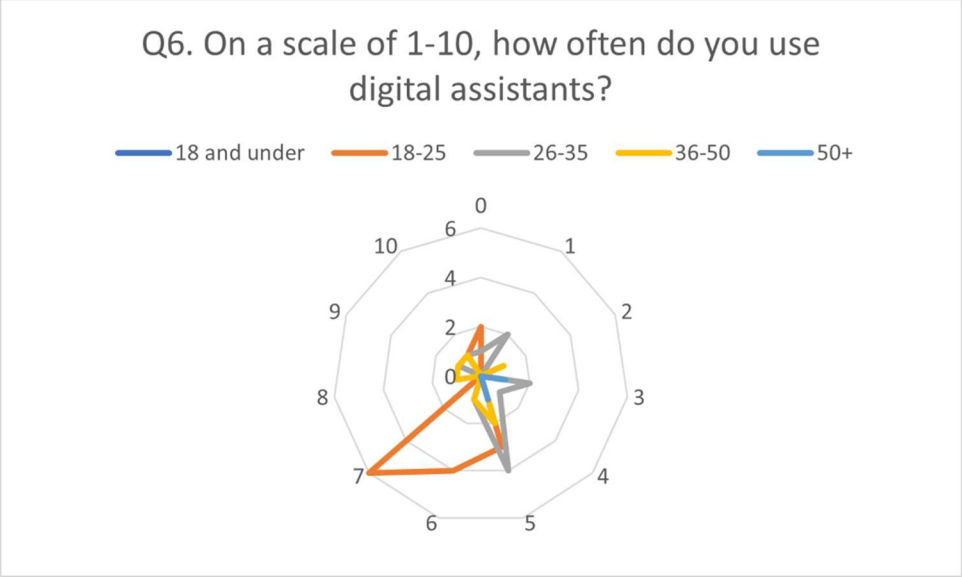

Figure 47: Age-based opinion about the frequency of use of digital assistants

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 47 shows information about the frequency of use of digital assistants for different age groups. Figure 47 indicates that the users of age group 18-25 voted 7, the users of age group 26-35 voted 1,3 and 5, the users of age group 36-50 voted 2 and 5 and the users of the age group 50+ voted 5 from the range of 0 to 10 regarding their frequency of use of digital assistants. Hence, Figure 47 indicates that users of all age groups use digital assistants occasionally.

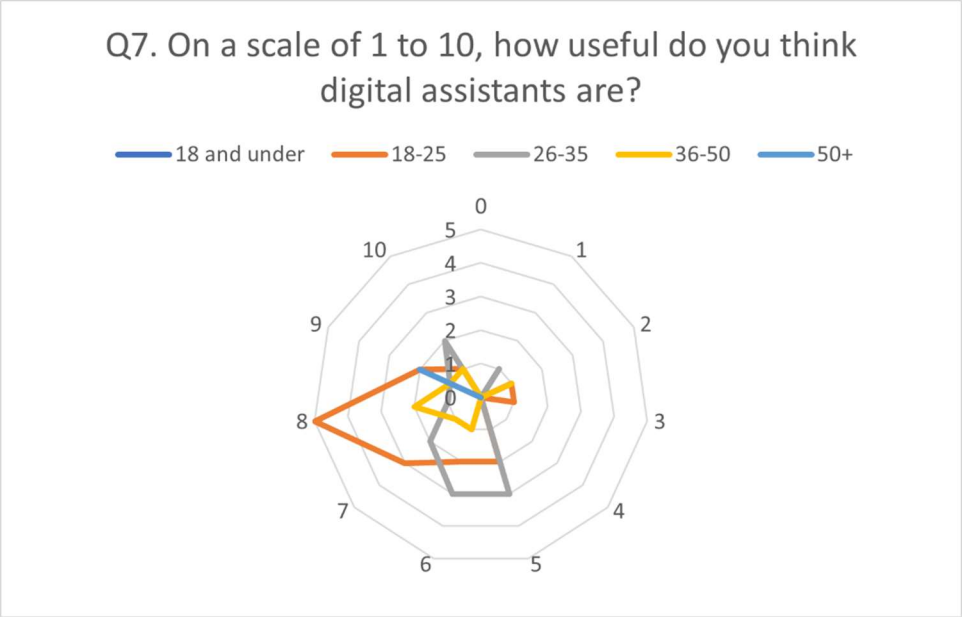

Figure 48: Opinion about the usefulness of digital assistants based on the age group of the users

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 1, 2, 3, 4, and 5 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 48 gives information about the opinions of the users belonging to different age groups about the usefulness of digital assistants. The users of age group 18-25 voted 8, the users of age group 26-35 voted 5 and 6, the users of age group 36-50 voted 5 and 8 and the users of the age group 50+ voted 9 from a rating scale of 0-10 about the usefulness of digital assistants. Hence, Figure 48 indicates that users of all age groups think that digital assistants are useful.

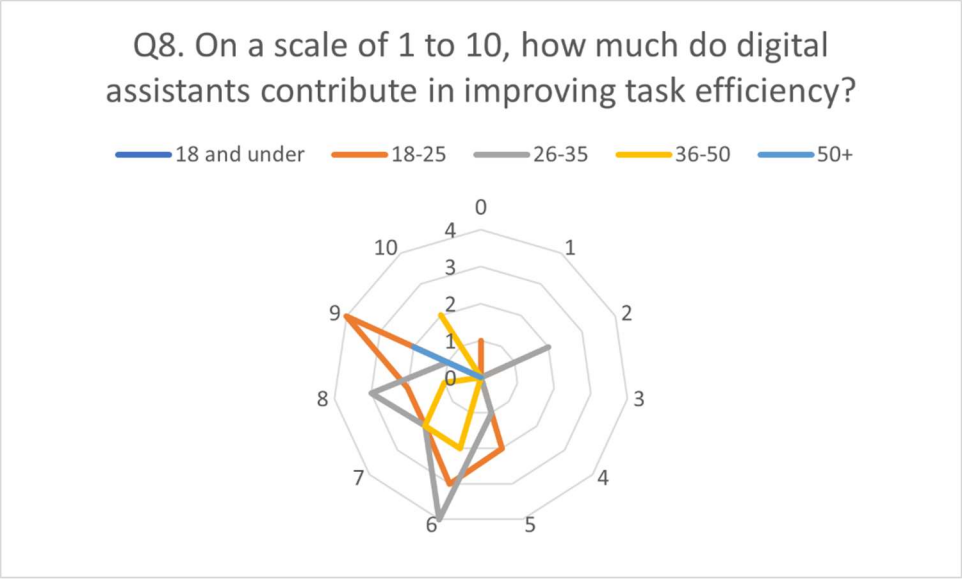

Figure 49: Age-based opinion about the task efficiency of digital assistants

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 1, 2, 3, and 4 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 49 shows information about the opinion of users belonging to different age groups about the task efficiency of digital assistants. Figure 49 indicates that the users of age group 18-25 voted 6 and 9, the users of age group 26-35 voted 6 and 8, the users of age group 36-50 voted 6,7 and 10, and the users of the age group 50+ voted 9 about the task efficiency of digital assistants. Hence, figure 49 indicates that users of all age groups think that digital assistants are task efficient.

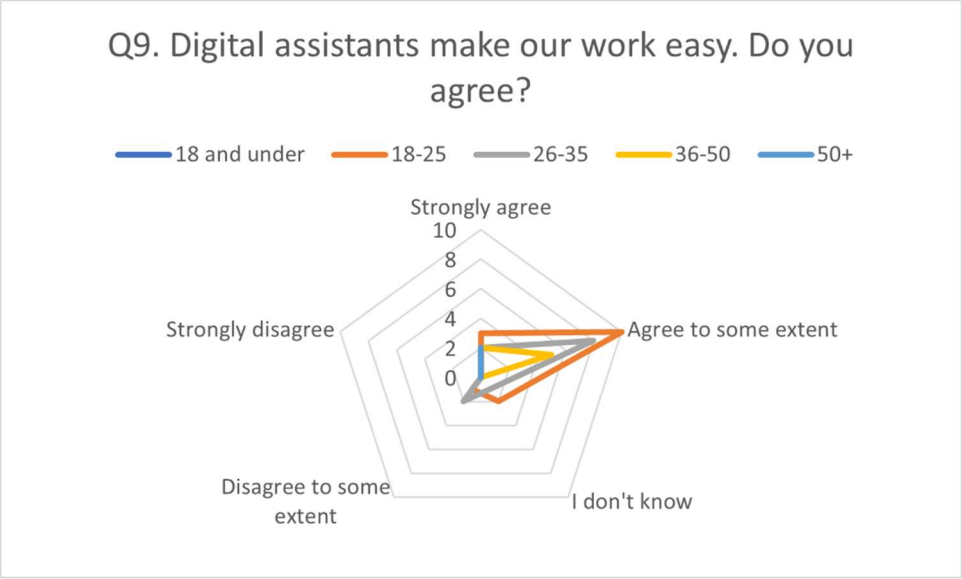

Figure 50: Opinion about digital assistants making work easy based on the age group of the user

The numbers 0, 2, 4, 6, 8, and 10 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 50 shows information about the opinion of the users of different age groups regarding digital assistants making work easy. The users of all age groups agree to some extent to the point that digital assistants make work easy. Hence, figure 50 indicates that users of all age groups think that digital assistants make work easy to some extent.

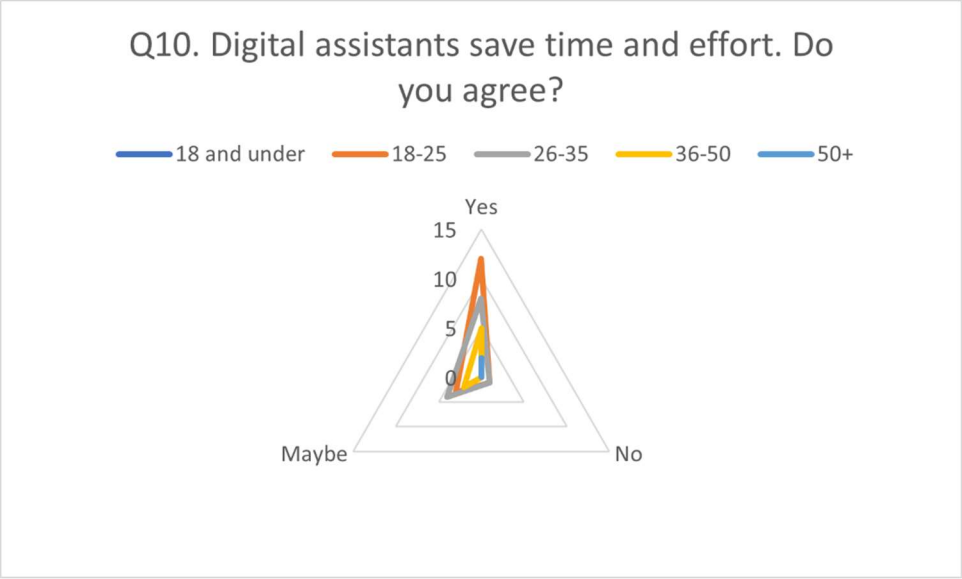

Figure 51: Opinion about digital assistants saving time and effort based on the age group of the users

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 51 shows information about the opinion of the users of different age groups regarding the point that digital assistants save time and effort. The users of all the age groups voted "Yes" as their opinion about digital assistants saving time and effort. Some users from all age groups voted "Maybe" as their opinion about digital assistants saving time and effort. Hence, Figure 51 indicates that users of all age groups think that digital assistants save time and effort.

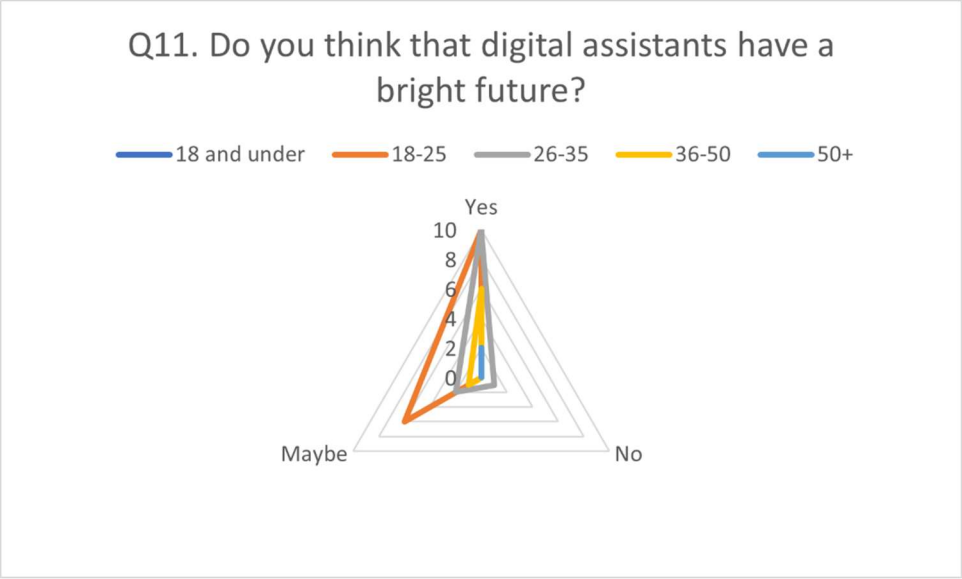

Figure 52: Opinion about digital assistants having a bright future based on the age group of the users.

The numbers 0, 2, 4, 6, 8, and 10 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 52 shows information about the opinion of the users of different age groups regarding the future of digital assistants. The users of all the age groups voted “Yes” as their opinion about digital assistants having a bright future. Some users of the age group 18-25 voted “Maybe” as their opinion about digital assistants having a bright future. Hence, Figure 52 indicated that users of all age groups think that digital assistants have a bright future.

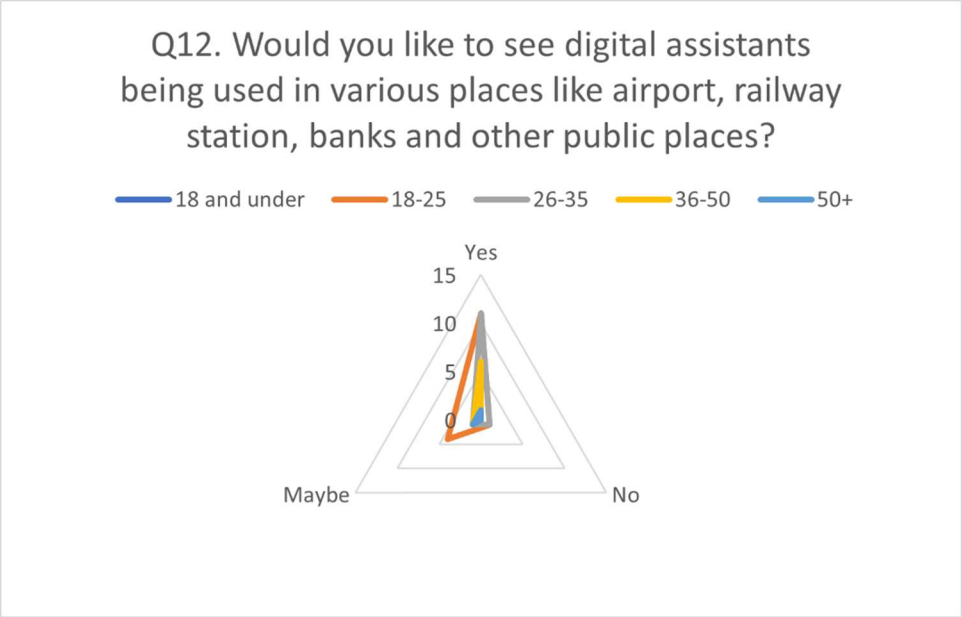

Figure 53: Opinion about the implementation of digital assistants at public places based on the age group of the users.

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 53 shows information about the opinion of the users of different age groups regarding the implementation of digital assistants in public places. The users of all the age groups voted" Yes" as their opinion about seeing digital assistants being implemented in public places. Some users of the age group 18-25 voted "Maybe" as their opinion. Hence, Figure 53 indicates that users of all age groups think that digital assistants should be implemented in public places.

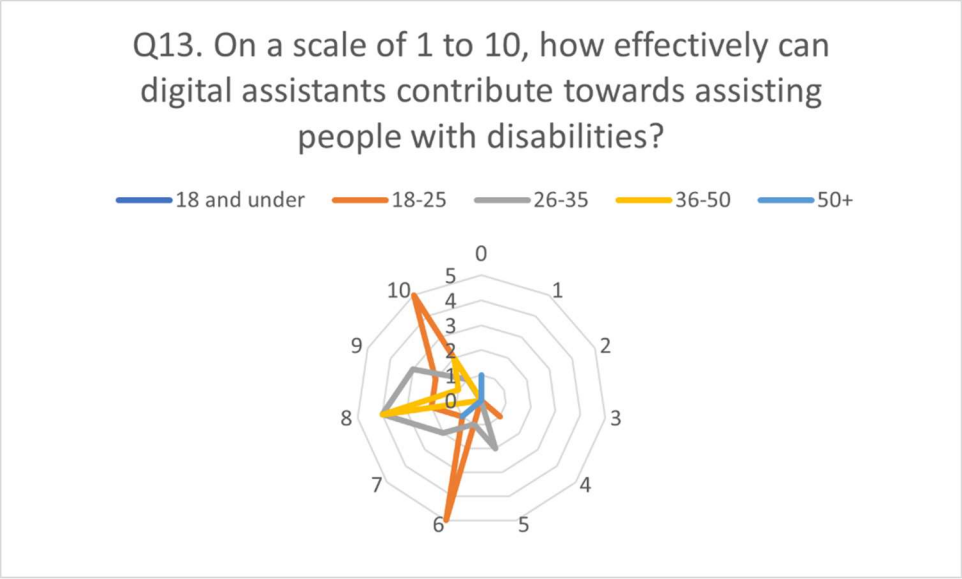

Figure 54: Opinion about digital assistants assisting people with disabilities by users of various age groups

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 1, 2, 3, 4, and 5 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 54 shows information about the opinion of the users belonging to different age groups about digital assistants being able to assist people with disabilities. The users of the age group 18-25 voted 4, 6 and 10, the users of age group 26-35 voted 5,8 and 9, the users of age group 36-50 voted 8 and the users of the age group 50+ voted 7 as their opinion about digital assistants being able to assist people with disabilities. Hence, Figure 54 indicates that users of all age groups think that digital assistants can help people with disabilities.

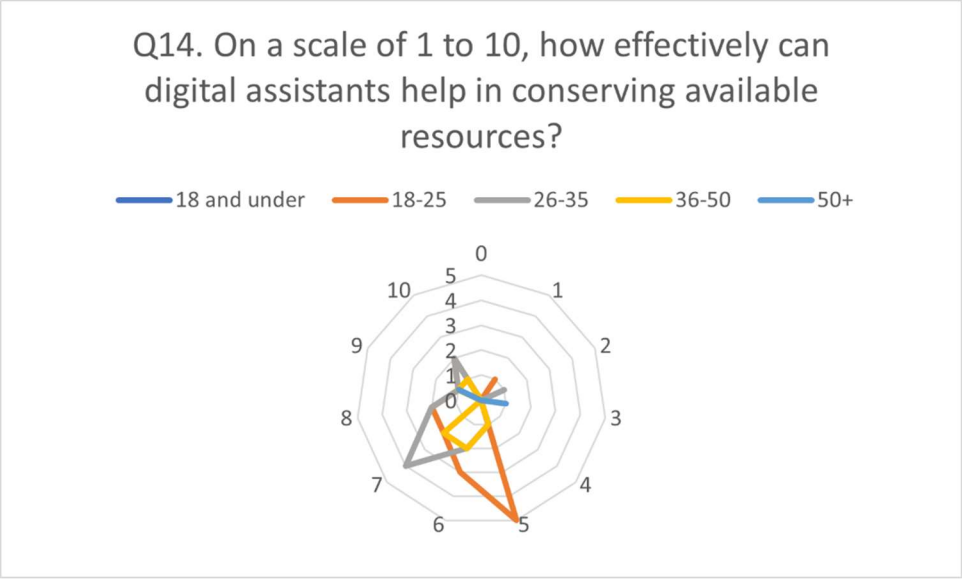

Figure 55: Opinion about digital assistants helping in conserving available resources by users belonging to various age groups

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 1, 2, 3, 4, and 5 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 55 shows information about the opinion of the users belonging to different age groups regarding digital assistants being able to help in conserving available resources. The users of age group 18-25 voted 5 and 8, the users of age group 26-35 voted 7, the users of age group 36-50 voted 6 and 7 and the users of the age group 50+ voted 3 as their opinion about digital assistants being able to help in conserving the available resources. Hence, Figure 55 indicates that users of all age groups except the age group of 50+ think that digital assistants can help in conserving the available resources.

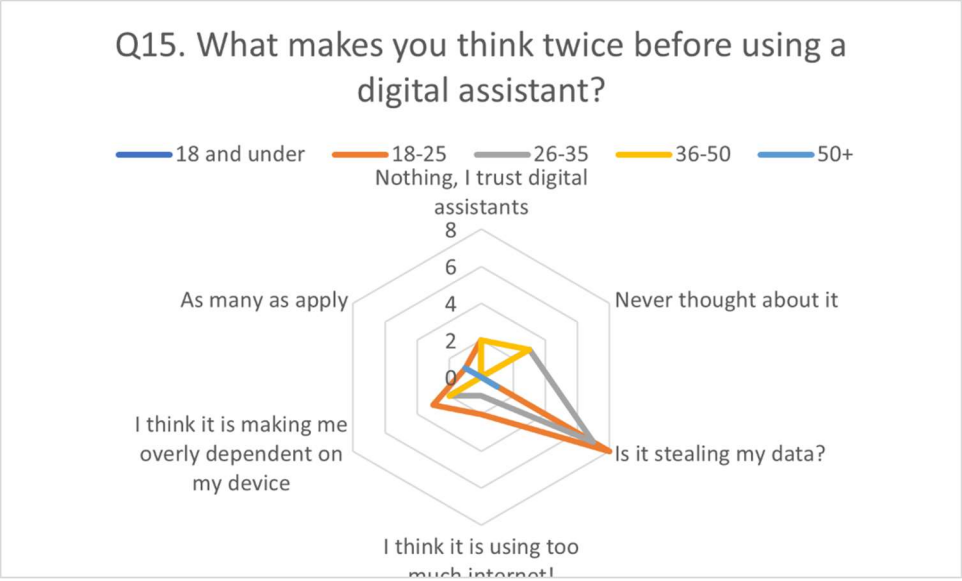

Figure 56: Concerns of using digital assistants for people of different age groups

The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 56 gives information about the opinion of the users of different age groups regarding the concerns of digital assistants. The users of the age group 18-25 are concerned about data theft and that digital assistants are making them overly dependent on technology, the users of the age group 26-35 think that digital assistants can steal their data and can make them overly dependent on technology, the users of the age group 36-50 think that digital assistants are making them overly dependent on technology and the users of the age group 50+ think that digital assistants can steal their data. Hence, the users of all age groups have a common concern while using digital assistants that is data privacy.

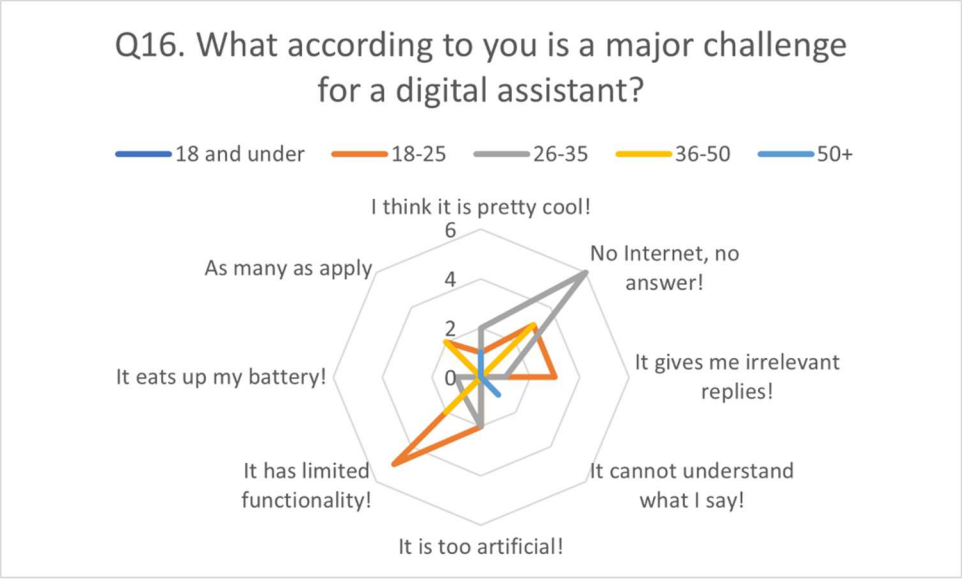

Figure 57: Opinion of users of different age groups about the challenges of using digital assistants.

The numbers 0, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 57 shows information about the opinion of users belonging to different age groups regarding the challenges of using digital assistants. The users of the age group 18-25 think that digital assistants give irrelevant replies, and have limited functionality, the users of the age group 26-35 think that unavailability of the Internet is a challenge for digital assistants, the users of the age group 36-50 think that unavailability of the Internet and a limited set of functionalities are the challenges for digital assistants and the users of the age group 50+ think that digital assistants cannot understand the user commands.

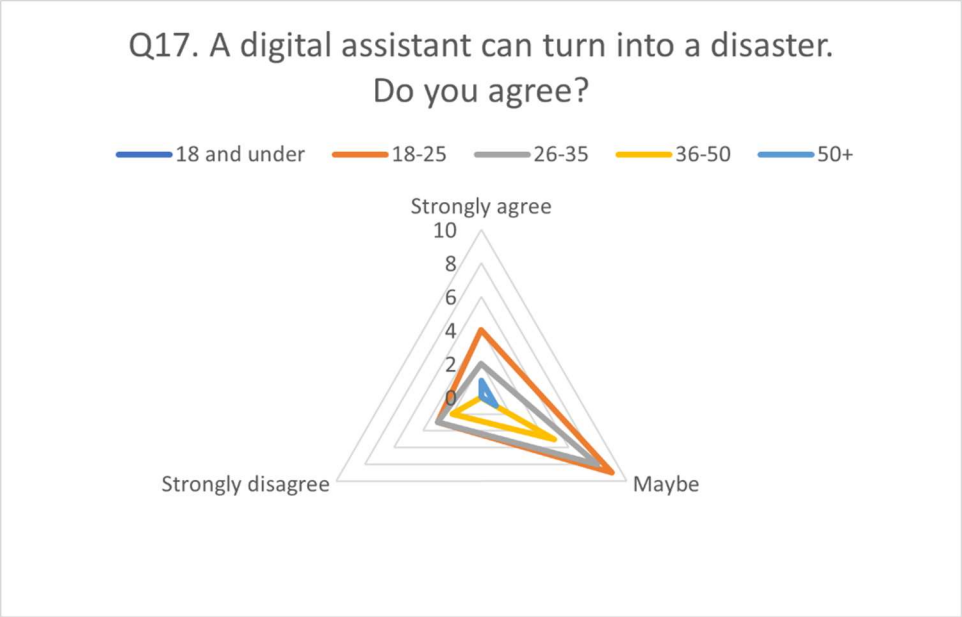

Figure 58: Opinion of users of different age groups regarding the possibility of a digital assistant to turn into a disaster

The numbers 0, 2, 4, 6, 8, and 10 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 58 shows information about the opinion of users of different age groups regarding the possibility of digital assistants turning into a disaster. The users of all age groups think that digital assistants may turn into a disaster as they voted “Maybe”. The users of the age group 50+ think that digital assistants can turn into a disaster as they voted “Yes”.

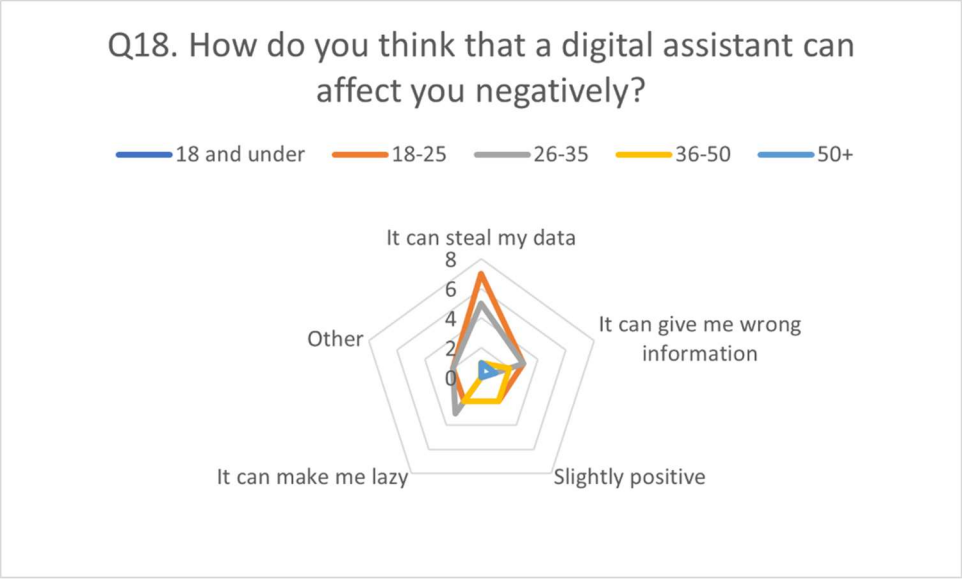

Figure 59: Opinion of users of different age groups regarding the negative effects of using digital assistants.

The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various age groups. Figure 59 shows information about the opinions of the users belonging to different age groups regarding the negative effects of using digital assistants. The users of the age group 18-25 think that digital assistants can steal their data and can give them wrong information, the users of the age group 26-35 think that digital assistants can make them lazy and can steal their data, the users of the age group 36-50 think that digital assistants can make them lazy and the users of the age group 50+ think that digital assistants can steal their data. Hence, Figure 59 indicates that users of all age groups are concerned about the possibility of digital assistants stealing their data.

Analysis Based on the Profession of the Users

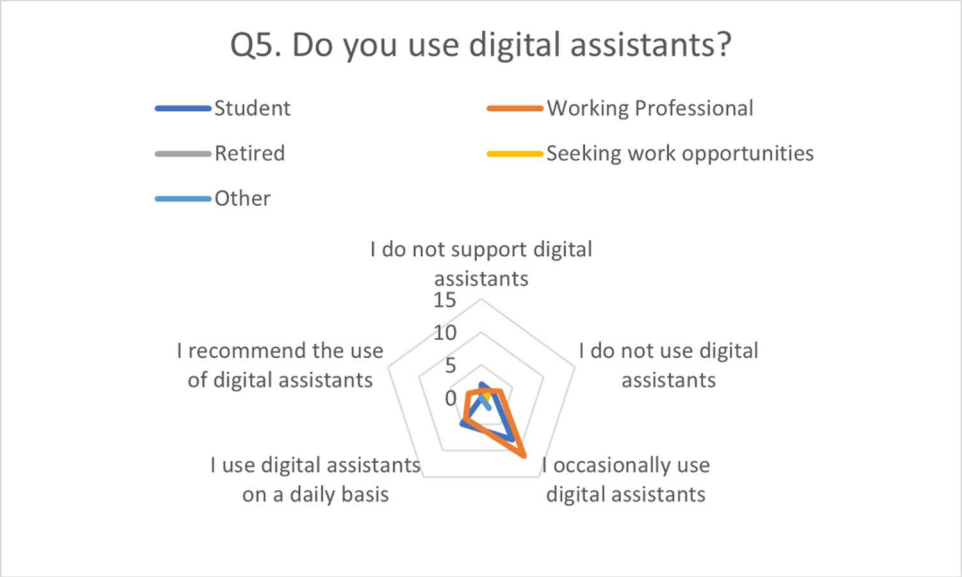

Figure 60: Use of digital assistants based on the profession of the users

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 60 gives information about the use of digital assistants by users having different professional backgrounds. The dark blue line represents students, the grey line represents retired personnel, the orange line represents working professionals, the yellow line represents professionals who are seeking work opportunities, and the light blue line represents other professionals who are not a part of any of the above-mentioned categories. Figure 60 indicates that professionals of all professional backgrounds prefer using digital assistants occasionally. Figure 60 also indicates that some working professionals recommend the use of digital assistants.

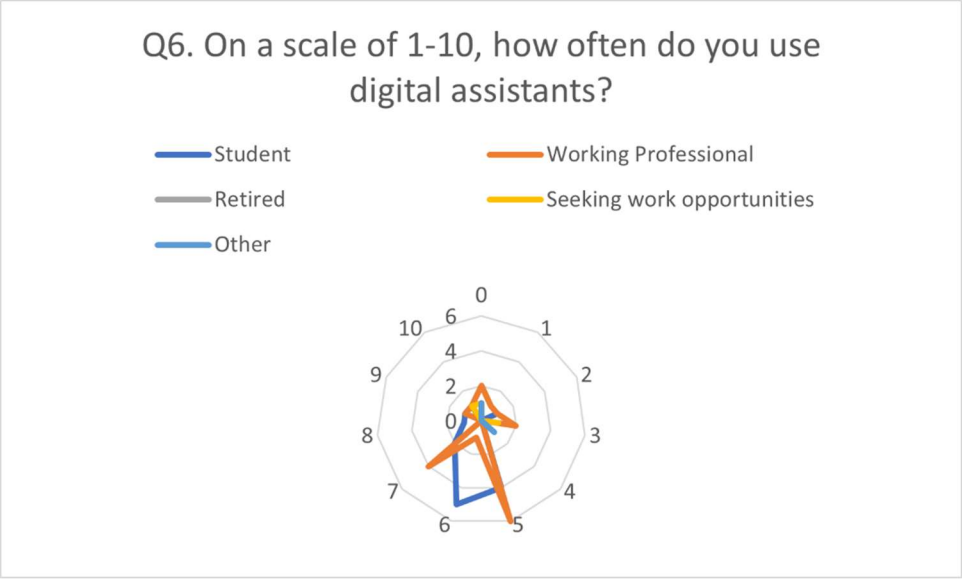

Figure 61: Opinion of users with different professional backgrounds about the frequency of use of digital assistants

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 2, 4 and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 61 gives information about the frequency of use of digital assistants for users belonging to different professional backgrounds. The frequency of use was rated from 0-10. Students voted 6, and working professionals voted 3, 5, and 7, professionals seeking work opportunities voted 3 and other professionals voted 4 as their frequency of use of digital assistants. Hence, Figure 61 indicates that the users having different professional backgrounds have a unique frequency of use for digital assistants.

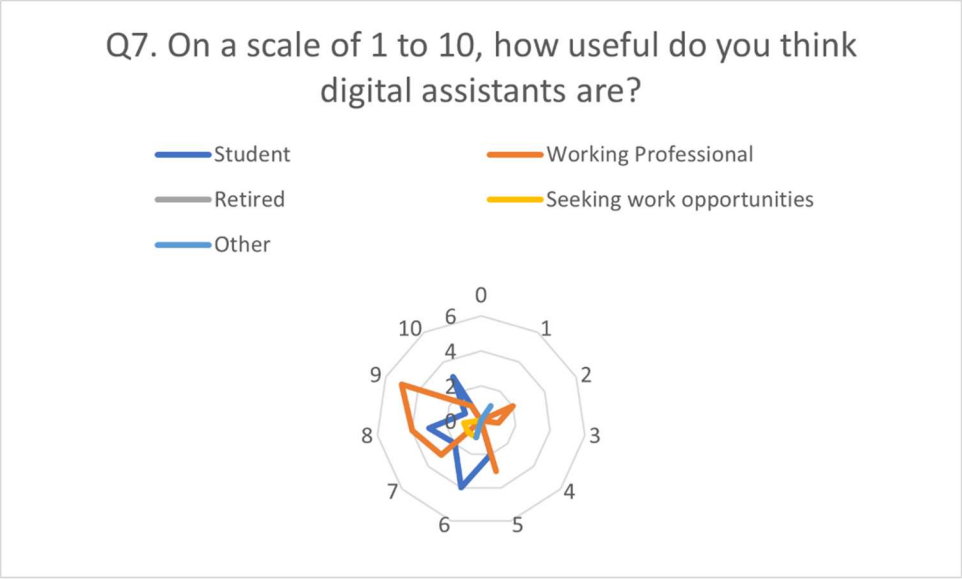

Figure 62: Opinion of users from different professional backgrounds regarding the usefulness of digital assistants.

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 62 gives information about the opinion of users of different professional backgrounds regarding the usefulness of digital assistants. Students voted 6,7, and 10, and working professionals voted 2, 5, and 9, professionals seeking work opportunities voted 7 and other professionals voted 6 as their opinion regarding the usefulness of digital assistants. Hence, Figure 62 indicates that users of different professional backgrounds have a unique opinion regarding the usefulness of digital assistants.

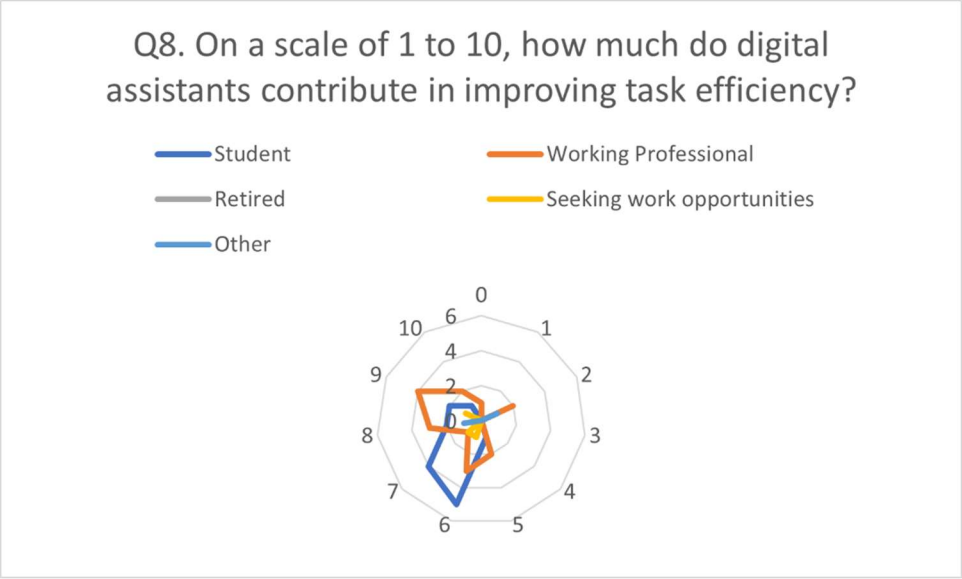

Figure 63: Opinion of users from different professional backgrounds regarding the task efficiency of digital assistants.

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 63 gives information about the opinion of the users belonging to different professional backgrounds regarding the task efficiency of digital assistants. Figure 63 indicates that students voted 6 and 7, working professionals voted 6 and 9, professionals seeking work opportunity voted 7 and other professionals voted 7 as their opinion about the ability of digital assistants to improve task efficiency. Hence, Figure 63 indicates that users from different professional backgrounds think that digital assistants are task efficient.

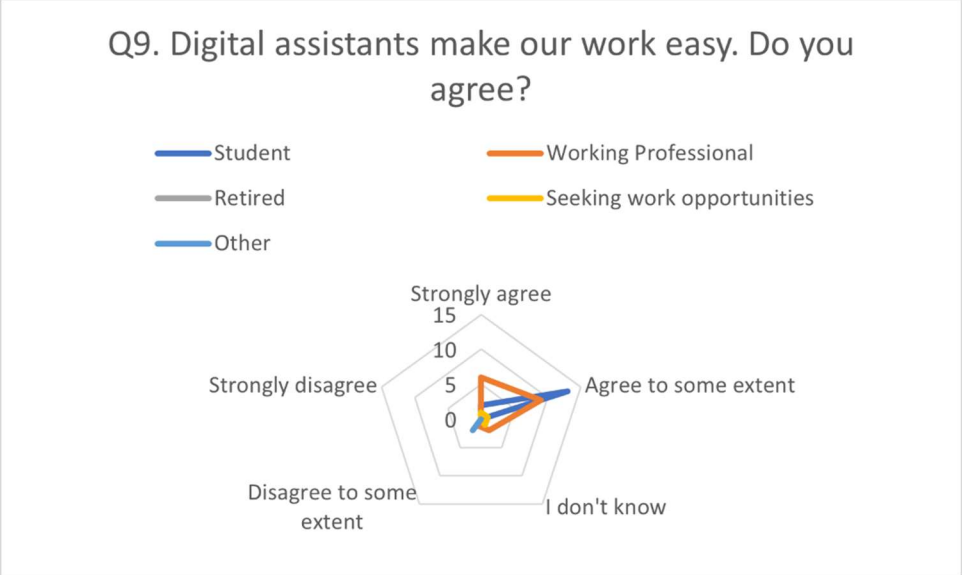

Figure 64: Opinion of users belonging to different professional backgrounds about digital assistants making work easy.

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 64 gives information about the opinion of users from different professional backgrounds regarding digital assistants making work easy. Figure 64 indicates that users belonging to all professional backgrounds think that digital assistants make work easy.

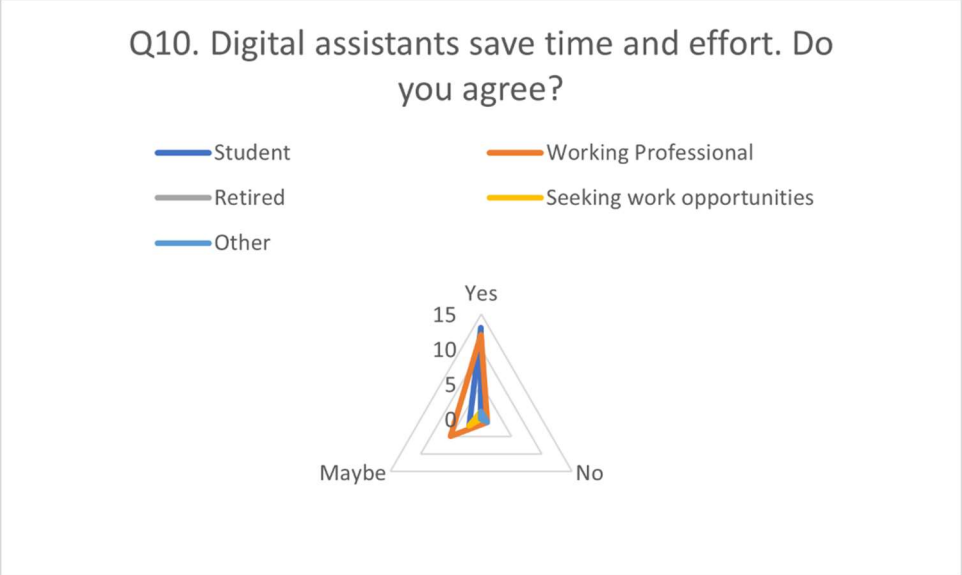

Figure 65: Opinion of users belonging to different professional backgrounds about digital assistants saving time and effort.

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 65 gives information about the opinion of the users belonging to different professional backgrounds regarding digital assistants saving time and effort. Figure 65 indicates that users from all professional backgrounds voted "Yes" about digital assistants saving time and effort. Hence, Figure 65 indicates that users from all professional backgrounds agree to the point that digital assistants can help in saving time and effort.

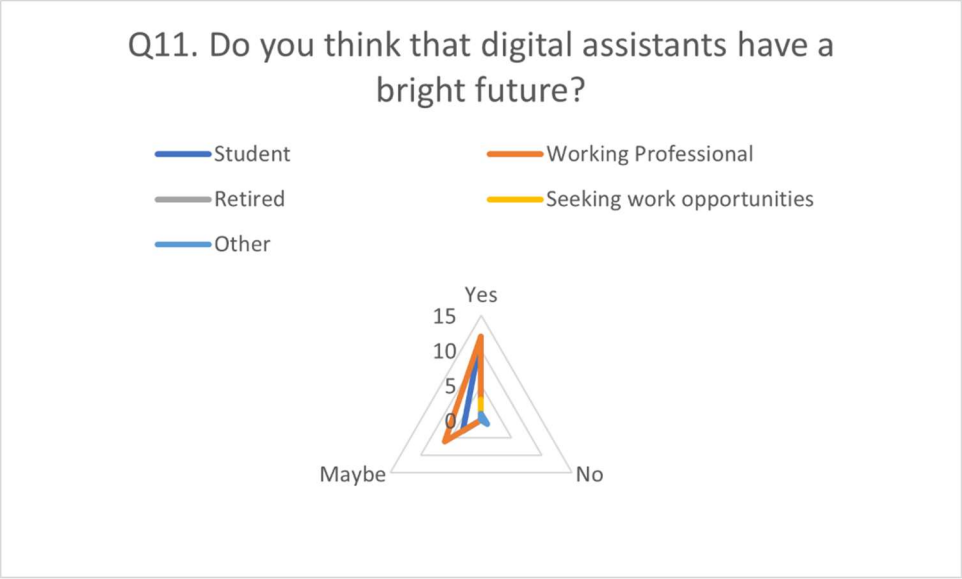

Figure 66: Opinion of users from different professional backgrounds about the future of digital assistants.

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 66 shows information about the opinion of users of different professional backgrounds regarding the future of digital assistants. The users from all the professional backgrounds voted "Yes" as their opinion about digital assistants having a bright future. Hence, Figure 66 indicates that the users belonging to all professional backgrounds think that digital assistants have a bright future.

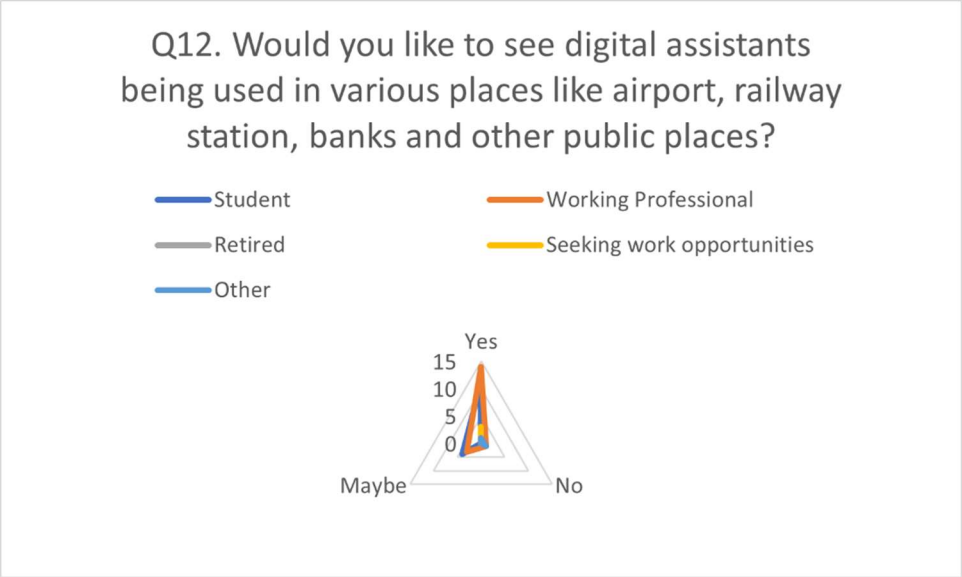

Figure 67: Opinion of users from different professional backgrounds regarding the implementation of digital assistants at public places.

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 67 gives information about the opinion of users belonging to different professional backgrounds regarding the implementation of digital assistants in public places. Figure 67 indicates that all the users voted "Yes" to implement digital assistants in public places. Hence, Figure 67 indicates that users from various professional backgrounds would prefer to see digital assistants being implemented in public places.

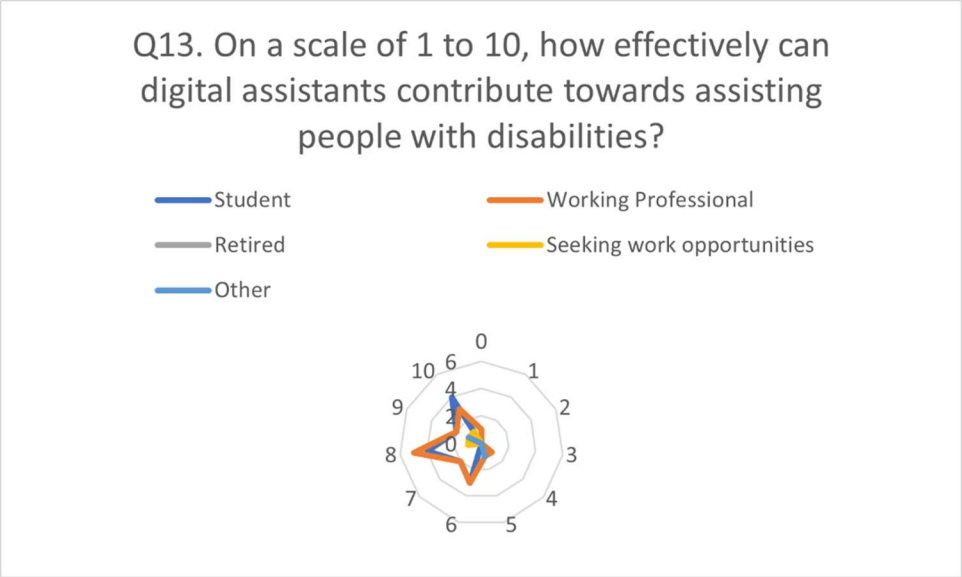

Figure 68: Opinion of users belonging to different professional backgrounds about digital assistants being able to help people with disabilities

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 1, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 68 gives information about the opinion of users from different professional backgrounds regarding the ability of digital assistants to assist people with disabilities. Figure 68 indicates that students voted 8 and 10, working professionals voted 6, 8, and 10, professionals seeking work opportunities voted 7 and other professionals voted 8 as their opinion about the ability of digital assistants to help people with disabilities. Hence, Figure 68 indicates that users from all professional backgrounds agree to the point that digital assistants can help people with disabilities.

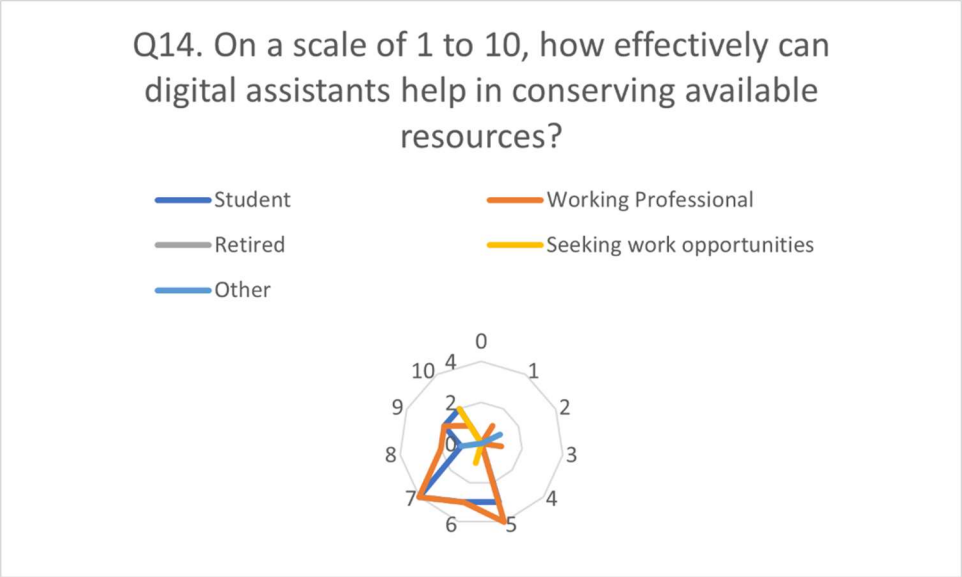

Figure 69: Opinion of users from different professional backgrounds about the ability of digital assistants to conserve available resources

The numbers 1 to 10 represent the score selected by the participants. The numbers 0, 2, and 4 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 69 gives information about the opinion of the users belonging to different professional backgrounds regarding the ability of digital assistants to help in conserving the available resources. Figure 69 indicates that students voted 5,7 and 9, working professionals voted 5,7 and 9, professionals seeking work opportunities voted 10 and other professionals voted 8 as their opinion about the ability of digital assistants to help in conserving the available resources. Hence, Figure 69 indicates the users from various professional backgrounds think that digital assistants can help in conserving the available resources.

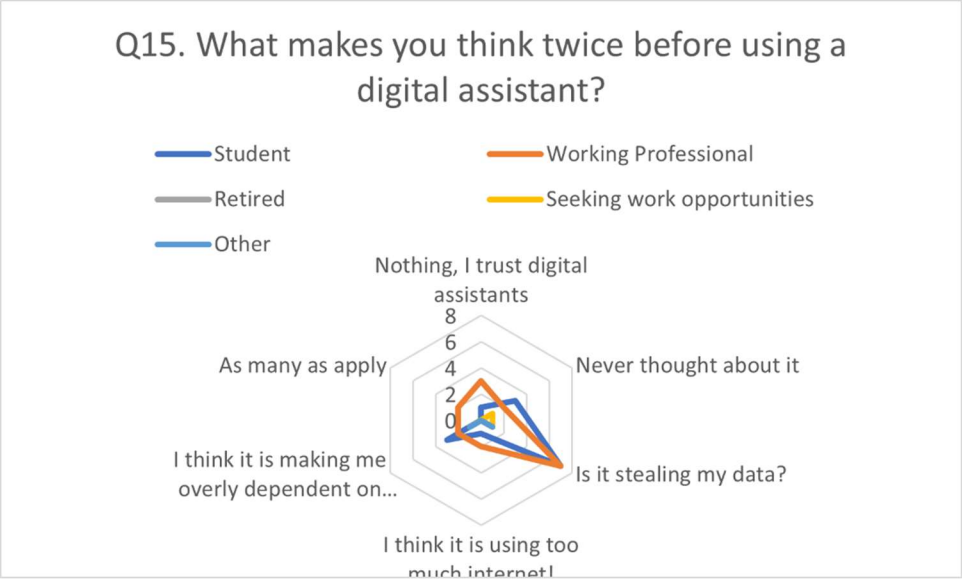

Figure 70: Opinion of users belonging to different professional backgrounds about the concerns of using digital assistants

The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 70 gives information about the concerns of users of different professional backgrounds about using digital assistants. Figure 70 indicates that students are concerned about data theft and digital assistants making them overly dependent on technology, the working professionals are concerned about data theft and have trust issues with digital assistants, the professionals seeking work opportunities are concerned about data theft and over-dependence on technology, and other professionals are concerned that digital assistants can make them overly dependent on technology. Hence, Figure 70 indicates that data theft and over-dependence on technology are the common concerns of users of different professional backgrounds regarding using digital assistants.

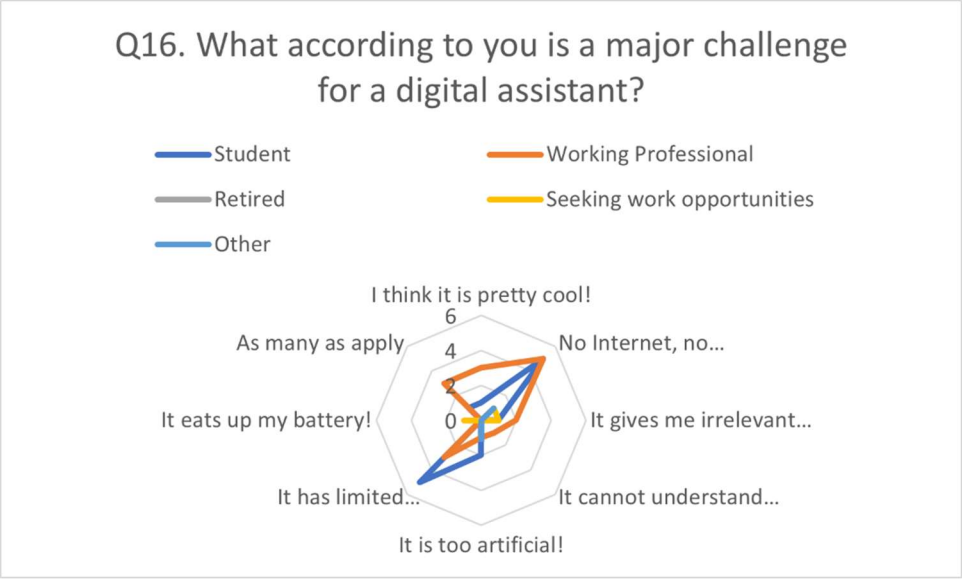

Figure 71: Challenges of using digital assistants based on the opinion of users from different professional backgrounds.

The numbers 0, 2, 4, and 6 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 71 gives information about the challenges faced by users of different professional backgrounds regarding using digital assistants. Figure 71 indicates that students think that unavailability of the Internet and limited functionality set, working professionals think that unavailability of the Internet, limited functionality set, irrelevant information, impact on battery life and inability to interpret user commands, professionals seeking work opportunities think that digital assistants providing irrelevant information and other professionals think that digital assistants being too artificial are the challenges of using digital assistants.

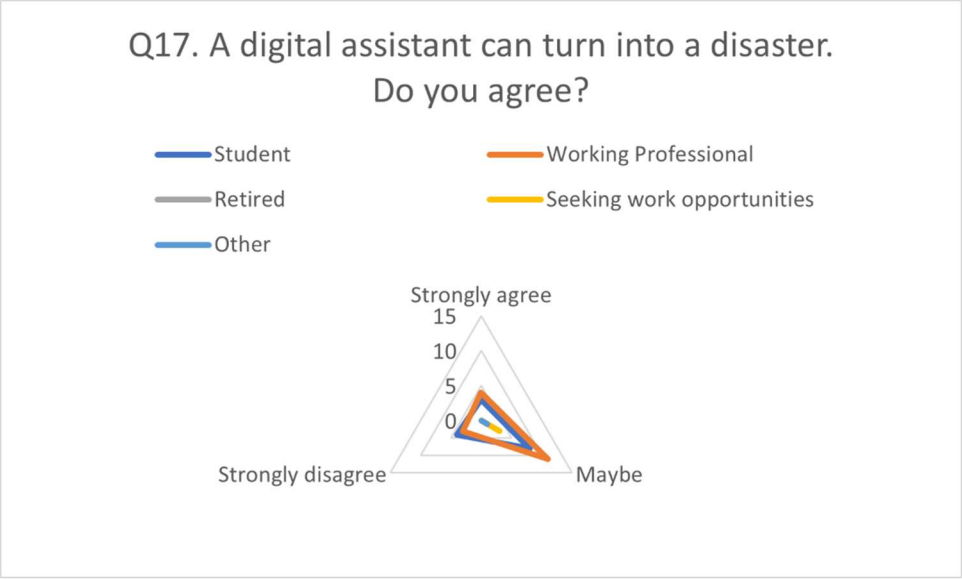

Figure 72: Opinion of the users belonging to different professional backgrounds about the possibility of digital assistants turning into a disaster

The numbers 0, 5, 10, and 15 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 72 gives information about the opinion of the users belonging to different professional backgrounds regarding the possibility of digital assistants turning into a disaster. Figure 72 indicates that users from all professional backgrounds think that digital assistants may turn into a disaster. Hence, Figure 72 indicates that the users neither agree nor deny the possibility of digital assistants turning into a disaster.

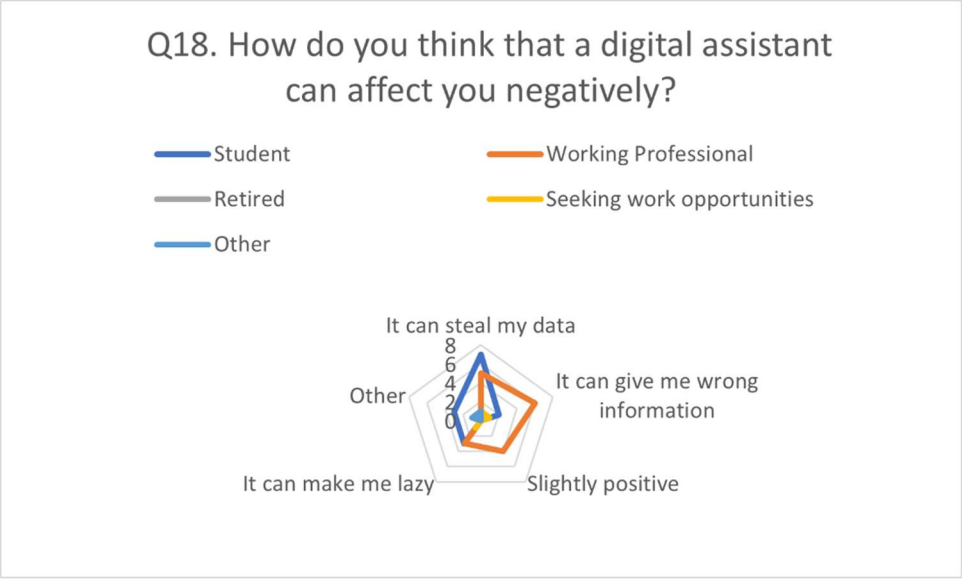

Figure 73: opinion of the users belonging to different professional backgrounds about the negative effects of using digital assistants.

The numbers 0, 2, 4, 6, and 8 represent the count of participants. The difference in the lines is because of the difference in the number of responses received from various professional backgrounds. Figure 73 gives information about the opinion of the users belonging to different professional backgrounds regarding the negative effects of using digital assistants. Figure 73 indicates that students think that digital assistants can steal their data, provide wrong information and can make them lazy, the working professionals think that digital assistant can steal their data, provide them with wrong information and make them lazy, the professionals seeking work opportunities think that digital assistants can provide them with wrong information and the other professionals think that digital assistants can make them lazy. Hence, Figure 73 gives information about the opinion of the challenges that the users from different professional backgrounds think digital assistants can pose.

Analysis based on the Voluntariness of use

Voluntariness of use represents the acceptance rate of the user for a given technology. For this research, questions 5 and 11 were framed to obtain information about the users' acceptance for digital assistants. The analysis of questions 5 and 11 can be found below.

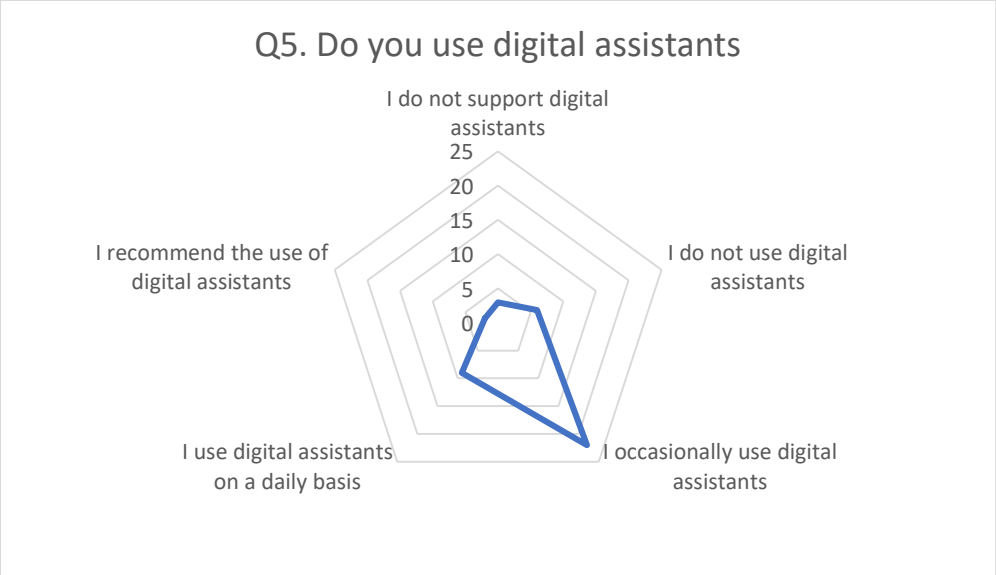

Figure 74: Analysis of the voluntariness of the use of digital assistants

The numbers 0, 5, 10, 15, 20, and 25 represent the count of participants. Figure 74 gives information about the voluntariness of the use of digital assistants. Figure 74 indicates that users prefer to use digital assistants occasionally. Hence, Figure 74 indicates that users prefer using digital assistants.

Figure 32 indicates that both males and females prefer to use digital assistants occasionally. Figure 46 indicates that users of all the age groups except the age group of 18-25 prefer using digital assistants occasionally. The users belonging to the age group 18-25 prefer to use digital assistants daily. Figure 60 indicates that users from all professional backgrounds prefer using digital assistants occasionally. Working professionals recommend the use of digital assistants. The analysis of Figures 32, 46, and 60 support the analysis of Figure 74.

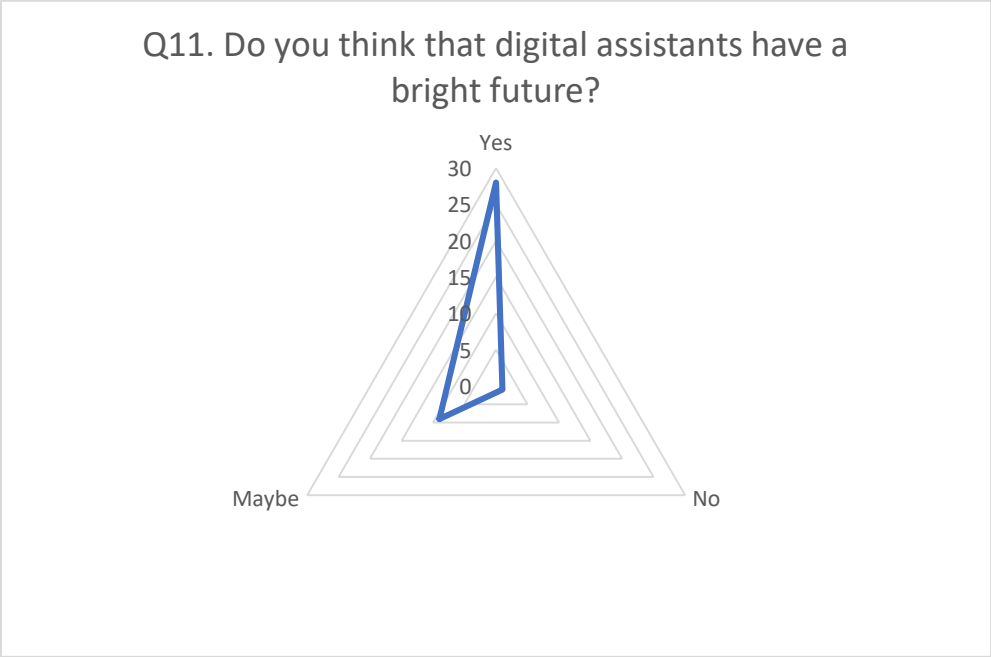

Figure 75: Analysis of the acceptance rate of digital assistants

The numbers 0, 5, 10, 15, 20, 25 and 30 represent the count of participants. Figure 75 gives information about the acceptance rate of digital assistants. Figure 75 indicates that users think that digital assistants have a bright future. Hence, Figure 75 indicates that users have a positive acceptance rate for the digital assistant's future.

Figure 38 indicates that both males and females think that digital assistants have a bright future. Figure 52 indicates that users of all age groups except the age group of 18-25 think that digital assistants have a bright future. The users of the age group 18-25 think that digital assistants may or may not have a bright future. Figure 66 indicates that users of all professional backgrounds except working professionals think that digital assistants have a bright future. Working professionals think that digital assistants may or may not have a bright future. Hence, it can be observed that the analysis of Figures 38, 52, and 66 supports the analysis of Figure 75. Hence, the overall analysis indicates a positive acceptance rate for digital assistants among its users.

5. Discussion

In this chapter, the outputs of different components of this research are compared. The information obtained by conducting an online survey and the information obtained from the online sources were compared with the output of the literature review. This comparison was made to answer the research questions for this research. For this research, the hypotheses are connected to the research questions. To conclude this research, the output of the online survey, the information obtained from online sources, and the information obtained from the literature review compared to answer the main research questions and the sub research questions. The correlation between the research questions and the hypotheses of this research can be found below.

Connection of research question with the hypotheses of this research:

Table 1 Correlation of research questions and hypotheses for this research

Research Question	Hypotheses
What are the factors affecting the use of digital assistants in day-to-day life (main research question)	H1, H2, H6, H8, H10, H11, H12
What are the standard application domains of digital assistants (sub research question)	H3, H4, H5, H13, H14, H15, H16
Which sectors can utilise digital assistants (sub research question)	H3, H4, H5, H13, H14, H15, H16
What are the challenges faced by the users in using digital assistants (sub research question)	H10, H14, H15, H16

Discussion for the Research Questions

5.1 Main research question

What are the factors affecting the use of digital assistants in day-to-day life

This question was to discover the factors that determine the performance of digital assistants in the market. Based on the results obtained from the literature review, online survey, and the information obtained from online sources, it was found that age, gender, educational background, and prior work experience affect the use of digital assistants.

These factors are related to the hypotheses of this research. The outcome of the research can be found below:

Outputs from the online survey

Based on the analysis of age, gender, educational background, and professional backgrounds of the participants, the following things can be observed:

- Participants of the age groups 18-25 and 26-35 have a higher usage of digital assistants as compared to the other age groups
- Digital assistants have more male users compared to female users
- The participants belonging to science background have a higher usage of digital assistants as compared to the use by the participants having commerce, arts, and other educational backgrounds
- Working professionals have a higher usage of digital assistants than students, retired professionals, and professionals seeking work opportunities.

Output from the online sources

Based on the information obtained from the online sources, the following observations can be made:

- There is an increase in the demand for digital assistants

- Users of all age groups use the services of digital assistants at least once a day
- Users belonging to the age group 25-49 have maximum interaction with digital assistants
- Users belonging to the age group of 18-24 and 25-54 prefer to use digital assistants through smartphones, tablets, speakers, and wearables.

Output from the literature review

Age

The analysis of the literature review indicates that young people find it easier to interact with digital assistants (Papoutsi & Drigas, 2017; Pillai et al., 2020). The literature review also indicates that young people have higher use of digital assistants than older people (Gürsoy et al., 2019; Kennington & Shukla, 2017).

Gender

The image indicates that males have higher use of digital assistants compared to females. The literature review indicates that digital assistants configured to female voice are accepted more in the market (Costa, 2018; Paul et al., 2017). An interpretation from this output can be made that the users have a high acceptance rate for digital assistants resembling female voice. The literature review also indicated that females have a lesser degree of trust for digital assistants than males (Zeng et al., 2017).

Educational background

The image indicates that people with a science background have a higher demand for digital assistants. The literature review indicates that science students are more likely to adapt to digital assistants than students of different streams (Choi et al., 2015). The literature review also interprets that as compared to other domains, digital assistants have a higher demand in the science and technology sector (Bartz-Beielstein, 2019; JacBoDska & Zajdel, 2018).

Work Experience

The information obtained from the online survey, online sources, and literature review indicate that working professionals and students have a higher demand for digital assistants as compared to other people. The literature review interpreted that digital assistants have multiple functionalities that can assist students and working professionals in their daily activities (Ai,

2019; Kudashkina et al., 2020). The literature review also interpreted that the current studies are being undertaken considering the education sector and corporate sector in mind (Vieira, 2017).

Conclusion for the main research question:

Based on the analysis of the online survey, information obtained from the online sources, and literature review, it was observed that the outcome obtained from the online survey and the information obtained from the online sources supports the information obtained from the literature review. Hence, age, gender, educational background, and professional work experience are the main factors affecting the performance of digital assistants.

5.2 Sub research questions

The main aim of sub research questions is to support the main research question. For this research, the sub-research questions focused on obtaining information about the standard applications of digital assistants, domains where digital assistants can be implemented and used, and the challenges that digital assistants may pose for their users. The output of this research for the sub research questions is given below.

Sub research question 1: What are the standard applications of digital assistants?

This question relates to hypothesis H3, H4, H5, H13, H14, H15, and H16. The main aim of this question was to shortlist the tasks and functions for which digital assistants are commonly used. To obtain the answer to this question, the output of the literature review and online survey were combined.

Output from the online survey:

Based on the analysis aimed at obtaining user opinion about the applications of digital assistants, the following things were observed:

- The participants prefer to use digital assistants as 52.38% of participants use digital assistants occasionally, and 21.43% of participants use digital assistants daily
- 60.53% of participants somewhat agree, and 23.68% of participants strongly agree that digital assistants task efficiency

- 71% of the participants think that digital assistants help in saving time and effort
- 26.32% participants voted 8, 21.05% participants voted 10 and 79% of participants voted 9 about the point that digital assistants can assist people with disabilities.

Output of the information obtained from online sources:

Based on the analysis of the information obtained from online sources, the following things can be observed:

- The users prefer to use digital assistants for home automation, task automation, and data processing
- 40% of adults use the voice search functionality of digital assistants at least once a day
- The users prefer to use the functionalities of voice-activated devices
- The users prefer to use digital assistants through a smartphone, speaker, tablet, and wearables.

Output from the literature review:

Digital assistants are used as a tool to retrieve the required information in time-critical tasks. Digital assistants are also used for automatic data processing (Costa, 2018). Digital assistants are used in smart home and smart office installations where they are embedded with other electronics devices (Coskun-Setirek & Mardikyan, 2017). Digital assistants are also used for monitoring health-related data for patients. Digital assistants are used in factories and powerhouses to assist professionals in their work (Haeb-Umbach et al., 2019). Digital assistants are also used in some public places for helping the public with relevant data. Moreover, digital assistants are also used to support the decision-making process (Kudashkina et al., 2020).

Conclusion for sub research question 1:

Based on the analysis of the information obtained from the online survey, online sources, and literature review, it can be observed that task automation and data processing are the standard applications of digital assistants. The output obtained from the online survey and the information obtained from online sources correlate and support the information obtained from the literature review.

Sub research question 2: What are the sectors that can utilise digital assistants?

The main aim of this question was to identify some opportunities for further research in digital assistants. To answer this question, information obtained from the literature review and the survey was used. This question relates to the hypothesis H3, H4, H5, H13, H14, H15, and H16. The output for this question can be found below.

Output from the online survey:

Based on the analysis aimed at obtaining user information about the demand for digital assistants, the following things were observed:

- 76.32% of participants would like to see digital assistants being implemented in places like airports, railway stations, banks, and other public places
- 26.32% of participants voted 8, 21.05 voted 10, and 15.79% voted 9 as their opinion about digital assistants being able to help people with disabilities
- 18.42% of participants voted 5, 18.42% voted 6 and 21.05% voted 7 as their opinion about participants think that digital assistants can help in conserving available energy.

Output of the information obtained from online sources:

Based on the analysis of the information obtained from the online sources, the following things can be observed.

- Task automation and data processing functionalities of digital assistants are in demand
- The users think that digital assistants can help in monitoring and processing data
- The users would like to see more functionalities of digital assistants in the entertainment, education, travel, news, and health and fitness sectors
- The users would like to use the home and office automation functionalities of digital assistants.

Output from the literature review:

Digital assistants use a combination of tools and technologies to function. Based on the requirements of the tasks to be accomplished, digital assistants can be configured with other mechanisms. Based on the literature review, it was discovered that digital assistants have a noticeable demand in the aviation sector, for clinical research, for healthcare services, for smart home and office environment, in data centres, and the research and development sector (Gürsoy

et al., 2019; Paul et al., 2017). The demand is based on the possible functionalities that digital assistants can provide. Based on the literature review and the responses collected from the online survey that users prefer digital assistants (Evanschitzky et al., 2015; Zeng et al., 2017). Based on the information, it can also be interpreted that users trust digital assistants for the functionalities provided by digital assistants (Purwanto et al., 2020). In the survey, the majority of the respondents answered that digital assistants have a bright future. Hence, the sectors mentioned above were obtained due to this research (Tabassum et al., 2019).

Conclusion for sub research question 2:

Based on the information obtained from the online survey, the information obtained from the online sources, and the information obtained from the literature review, it was observed that medical, travel, entertainment, education, news, and automation sector have a considerable demand for digital assistants.

Sub research question 3: What are the challenges faced by the users in using digital assistants?

The main aim of this question was to identify the concerns of the users in using digital assistants. This question relates to the hypotheses H10, H13, H14, and H15. More information about the answer to this question can be found below.

Output of the online survey:

Based on the analysis aimed at obtaining user opinions about the challenges of using digital assistants, the following observations were made:

- 42.11% users think that digital assistants are stealing their data and 18.42% users think that digital assistants are making them overly dependent on technology
- 31.58% of users think that unavailability of the Internet is a major challenge for digital assistants whereas 21.05% of users think that digital assistants have limited functionality
- 60.53% of users think that digital assistants may turn into a disaster
- 36.84% users think that digital assistants can steal their data, 23.68% users think that digital assistants can give them wrong information, and 18.42% of users think that digital assistants can make them lazy.

Output of the information obtained from online sources:

Based on the analysis of Figures 6, 7, 9, 10, and 12, it was observed that digital assistants store user data. The users prefer using the voice search functionality of digital assistants. Hence, there is a possibility that digital assistants can provide the wrong information for misinterpreted commands and user interactions. Digital assistants are preferred for their automation functionalities as observed in the previous sections; hence it is also possible that too much usage of digital assistants can lead to dependence on their functionalities. Moreover, to function, digital assistants need an Internet connection. This requirement of digital assistants makes them vulnerable to cyber threats. Hence, based on the analysis of the information obtained from the online sources, it can be interpreted that cyber threats, misinterpretation of user commands, and data privacy are the challenges faced by the users.

Output from the literature review:

A majority of the users are concerned about their data safety while using digital assistants (Malkin et al., 2019). Based on the literature review, it can also be seen that users feel that digital assistants are overly dependent on the Internet (Tabassum et al., 2019). Moreover, it can also be interpreted that there is an opportunity for further research for a digital assistant that can address the users' concerns (Pillai et al., 2020).

Conclusion for sub research question 3:

The output of the literature review, the output of the online survey, and the information obtained from the online sources indicate that data privacy is a common concern for the users of digital assistants. Users also think that digital assistants are inefficient in the absence of the Internet. Moreover, users also believe that digital assistants may provide false information occasionally.

5.3 Summary of the discussion of the research questions and hypotheses

Based on the information collected by undertaking the structured literature review and the online survey, it can be concluded that digital assistants are preferred and trusted by the users. Digital assistants are used in multiple domains such as the aviation sector, medical and healthcare sectors, corporate and home environments, and research and development. Data privacy is a common concern of the users of digital assistants. The research questions were addressed based on the output of the structured literature review and the online survey and the information collected from online sources. Finally, it can be stated that there is a good demand for digital assistants in the market. Hence, there is an opportunity to continue this research for improving the overall performance, trustworthiness, and functionalities of digital assistants.

6. Conclusion

This research was focused on the trends of digital assistants. This research conducted a structured literature review, an online survey, and analysed statistical data gathered from online sources. This research followed the UTAUT model for researching digital assistants. The literature review was divided into three sections, namely components and technologies used by digital assistants, applications of digital assistants, and challenges posed by digital assistants. By researching the components and technologies used by digital assistants, information about the concepts, tools, and technologies used by digital assistants was obtained. The study of components and technologies used by digital assistants made it possible to determine the functioning of digital assistants like data processing, information management, and task automation. The analysis of the components and technologies used by digital assistants helped determine the possible areas of improvement and the current research that may improve digital assistants by studying various components of assistants like the aviation sector, medical sector, defence sector, and the corporate sector. The study of applications of digital assistants helped to understand the demand for digital assistants in the market. By studying the application domains of digital assistants, it was also possible to identify the possibility of improvement for digital assistants for some functionalities like voice recognition, data privacy and confidentiality, and user interaction. Analysing the challenges posed by digital assistants, it was possible to understand the types of threats that may occur for the users of digital assistants like a cyber-attack, redirection to malicious websites on the Internet, or eavesdropping by hackers. Vulnerabilities of digital assistants like lack of efficient data security protocols, Internet protocols, and confidentiality of the user information could be discovered by studying the challenges posed by digital assistants. Through an online survey, it was possible to obtain a public opinion regarding digital assistants. The future of digital assistants could be predicted based on the responses gathered by the survey. The survey concluded that users prefer using digital assistants. The participants acknowledged that digital assistants contribute to increasing task efficiency and work efficiency. The users believe that digital assistants can assist people with disabilities and can also help conserve available resources.

The survey also concluded that the public feels that digital assistants have a bright future. The users acknowledged that they would like to see digital assistants implemented in public places. Data privacy was a common concern of participants regarding digital assistants. The process of gathering statistical data from online resources was conducted to provide support to the output of the structured literature review and the online survey. The statistical data gathered from multiple sources indicated that users prefer using digital assistants, users feel that digital assistants help in making everyday tasks easy, and users feel that data privacy can be a challenge while using digital assistants. This research also indicated that people with a science background and working professionals are prominent users of digital assistants based on the online survey and that people prefer using digital assistants occasionally.

6.1 Limitations

This research has these limitations:

- The online survey was unable to obtain sufficient responses to establish statistical significance
- This research was unable to incorporate more research tools such as experimentation and interviews to improve the outcome
- This research was unable to analyse the technologies and concepts that can be integrated into digital assistants.

This research mainly relied on public opinion, information obtained from online sources, and literature review to obtain insights about the trend of digital assistants. This research could have been further expanded by conducting experiments, observations and by increasing the reach of this research. This research also does not provide information about the implementation of digital assistants with other technologies. This research also lacked a proper marketing strategy to improve the number of participants for the online survey. Moreover, this research could have been further expanded based on the domain-specific applications of digital assistants.

6.2 Future Research

This research focused on obtaining information about the components and technologies used by digital assistants, applications of digital assistants, and challenges that may be posed by digital assistants to the users. This research can be expanded by narrowing the application domains of digital assistants like the aviation sector, medicinal research, and the defence sector. This research can be expanded by conducting a study of the technologies and concepts that can be integrated with digital assistants and by studying possible ways to overcome the limitations of digital assistants.

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Appendix

Survey link and questions

https://forms.office.com/Pages/ResponsePage.aspx?id=Ltijar83x06hB2iK2HPZr3XNwxk8T3BBv3NQ7VmE1VBUNElEUU9FT1pRRUQxTkYySzRMSE5LNjVDNi4u

Survey questions:

Question number	Question	Options
1	You are a:	• Male • Female • Prefer not to say • Do not want to say
2	What is your age group?	• 18-25 • 26-35 • 36-50 • 50+
3	What is your educational background?	• Science • Commerce • Arts • Other_____
4	You are a:	• Student • Working professional • Retired • Seeking work opportunities • Other_____

5	On a scale of 1-10, how often do you use digital assistants?	1 2 3 4 5 6 7 8 9 10
6	On a scale of 1 to 10, how useful do you think the digital assistants are?	1 2 3 4 5 6 7 8 9 10
7	On a scale of 1 to 10, how much do digital assistants contribute to improving someone's work efficiency?	1 2 3 4 5 6 7 8 9 10
8	Digital assistants make our work easy. Do you agree?	• Strongly agree • Agree to some extent • I don't know • Disagree to some extent • Strongly disagree

9	Digital assistants save time and effort. Do you agree?	• Yes • No • Maybe
10	Do you think that digital assistants have a bright future?	• Yes • No • Maybe
11	Would you like to see digital assistants being used in various places like airports, railway stations, banks and other public places?	• Yes • No • Maybe
12	On a scale of 1 to 10, how effectively can digital	1 2 3 4 5 6 7 8 9 10

	assistants contribute towards assisting people with disabilities?	
13	On a scale of 1 to 10, how effectively can digital assistants help in conserving available resources?	1 2 3 4 5 6 7 8 9 10
14	On a scale of 1 to 10, to what extent do you prefer using digital assistants in day to day life?	1 2 3 4 5 6 7 8 9 10
15	What makes you think twice before using a	• I trust digital assistants • Never thought about it • Is it stealing my data? • I think it is using too much internet!

	digital assistant?	• I think it is making me overly dependent on my device • Other_____
16	What according to you is a major challenge for a digital assistant?	• I think it is pretty cool! • No Internet, no answer! • It gives me irrelevant replies! • It cannot understand what I say! • It is too artificial! • It has limited functionality! • It eats up my battery! • Other_____
17	A digital assistant can turn into a disaster. Do you agree?	• Strongly agree • Maybe • Strongly disagree
18	How do you think that a digital assistant can cause trouble?	• It can steal my data • My devices can be hacked • It can give me wrong information • It can make me lazy • Other_____

Ethics forms 	Research and Postgraduate Office (RPGO) Human Ethics in Research Group (HERG)

LOW-RISK HUMAN ETHICS IN RESEARCH APPLICATION FORM

Please refer to the Ethics Guidelines before completing this application.

The RPGO is located at the City Campus, D-Block (Offices D2.22 – D2.24), email research@wintec.ac.nz or phone Megan Allardice on Ext. 3582 for more information.

Please see the last page of this document for detailed instructions for completing this form.

	Impact of digital assistants in day to day life

2.1	Primary researcher's name	Karmin Dave
2.2	School//Centre/Unit	WINTEC (Centre for Information technology)

2.3	Contact Details (Telephone and Email)	Kardav09@student.wintec.ac.nz, +64211606608
2.4	Is this application a:	■ Student Application Staff Application
2.5	If this is a student application, please provide the Module code here	INFO901/2002
2.6	Is this project a staff application that utilises work partially or wholly undertaken by students who are not participants (e.g. data collection undertaken by a researcher 'ss class)?	It is not a staff application. The application is for my student research proposal.
2.7	If so, please clearly describe what the role of these students is to be in this research, what the work will be used for explicitly (including any issues regarding authorship of research outputs such as journal articles), and what steps have been taken to ensure students are aware of this.	N/A
2.8	Name of other Researcher(s) and positions. (If this is a student application, please provide the name(s) of the project supervisor(s) and indicate that they are supervisors here.)	Dr. Kay Fielden(Supervisor)
2.9	Contact Details of other researchers and supervisors (Telephone and Email)	Dr. Kay Fielden(Supervisor) – Kay.Fielden@wintec.ac.nz Karmin Dave (Researcher) – kardav09@student.wintec.ac.nz, +64211606608

2.10	Is this application:	A new application

	The projected start date for **data collection** *(once this ethics application is approved. Please note, projects can only begin once applications have been approved, regardless of the level of risk)*: Projected end date: end of the semester

Research purpose and objectives:

- The primary purpose of this research is to study the challenges faced by users in using digital assistants
- This research focuses on getting information about the standard applications of digital assistants.
- This research also focuses on getting information about the currently ongoing research for expanding the application base of digital assistants.
- This research focuses on gaining public opinion about digital assistants

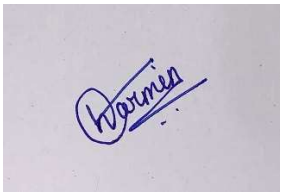
- Finally, this research aims in comparing the data obtained from the literature review and public survey to find the commonalities between the expected application domains of virtual assistants and existing applications of virtual assistants,

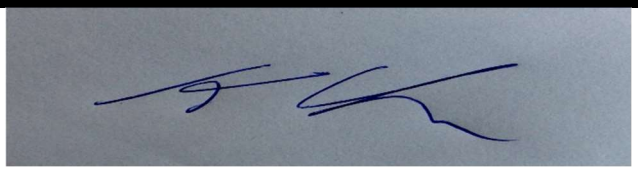
Project methodology:

- For this research, quantitative research methodology will be used
- A literature review will be conducted for finding information about the application domains of virtual assistants and ongoing research for expanding the application domain of virtual assistants
- A public survey will be conducted to get public opinion about virtual assistants and to get information regarding the public's perspective of the effectiveness of virtual assistants
- The target audience for this research will be students, working professionals, retired people, and general public
- The quantitative research methodology will be used to compare the inputs obtained from the literature review and public survey

Please describe below the process that you have undergone to discuss and analyse the ethical The factors considered while planning this research, as mentioned below:

- **Risk of Harm**
  - This research will involve a literature review and a public survey.
  - The public survey contains general questions that do not involve collecting any information that may create a sense of discomfort in the participants.
- **Anonymity and Confidentiality**
  - This research involves a public survey which aims at collecting general information from the participants.
  - No questions are asked, which may reveal the identity of the participants. The public survey does not aim to collect any confidential information.
- **Informed Consent** –
  - This research involves a public survey.
  - The participants are informed about the topic of the survey, and the purpose of the research before beginning the survey.
  - The participant information sheet is shared with the participants before the survey begins.

Researcher(s) signature(s) (the <u>name and signature</u> of all researcher(s) are to be included):		
Karmin Dave		7/01/2021

Primary supervisor's signature (if this is a student application):		
Dr Kay Fielden		15/08/2020

Research Leader's signature:		
Karmin Dave		07/01/2020

HERG Chairperson or delegated representative' 'ss signature (RPGO use only):		

COMPLETING THIS FORM

Please note: A low-risk research project is one in which the nature of the potential/actual risk of harm to participants or the researcher is minimal and no more than is normally encountered in daily life. If, as a staff member, you are new to research or are in any doubt as to which application to submit, please consult with your Research Leader. If you are a student, your supervisor will be able to give you advice. If you are still in any doubt, do not hesitate to consult the RPGO.

Specific Instructions

- All questions are to be answered. Note the questions within require a mix of descriptions, yes/no answers and cross the box (**Double-click on checkboxes with your mouse and select" Check" from the options under" Default Valu"**).
- Research Leaders need to review the information in this form and sign it off prior to the application being made to the RPGO.
- Please forward one signed original copy to the RPGO, together with an electronic version to research@wintec.ac.nz.
- Low-Risk Human Ethics in Research Applications also need to be accompanied by a copy of the Information Sheet, Consent Form, and any Questionnaires or Interview Schedules for consideration. If Questionnaires/ Schedules are not yet confirmed, please supply the latest draft.
- No questions are to be deleted, even those that you feel you are not required to answer.
- No part of the research requiring ethical approval should commence prior to approval being confirmed.
- Applicants will receive official confirmation of submission via email from the RPGO once all conditions of this form have been completed.
- If you want to apply for an extension on a previously approved project, please contact the RPGO, as you will probably not need to submit a separate application.
- Applicants will be advised of the outcome of their application to the Human Ethics in Research Committee **no later than ten working days** after the completed and confirmed submission of this application.

Research project title:	**Impact of digital assistants in day to day life**
Name of primary researcher:	Karmin Dave

Attached please find (as applicable) in the order listed below	
Completed HERG Low-Risk Application Form	**Yes** No
Consent Form for participants	**Yes** No
Information Sheet for participants	**Yes** No

Copy of Focus Group Questions, Interview Schedule, or similar	**Yes** No

Project Title: Factors affecting the use of digital assistants in day to day life

Participant Consent Form

(one copy to be retained by the Research Participant and one copy to be retained by the researcher)

I…… participant's name) consent to being a participant in the research mentioned earlier project, and I attest to the following:

1. I have been informed thoroughly of the purpose and aims of this project
2. I understand the nature of my participation
3. I understand the benefits that may be derived from this project

4. I understand that I may review my contributions at any time without penalty

5. I understand that I will be treated respectfully, fairly and honestly by the researcher/s, and I agree to treat the other participants in the same way

6. I understand that I will be offered the opportunity to debrief during or after this project

7. I have been informed of any potentially harmful consequences to me of taking part in this project

8. I understand that I may withdraw from the project at any time (without any penalties)

9. I understand that my anonymity and privacy are guaranteed, except where I consent to waive them

10. I understand that information gathered from me will be treated confidentially, except where I consent to waive confidentiality

11. I agree to maintain the anonymity and privacy of other participants and the confidentiality of the information they contribute.

Participant……Date……

Principal Researcher……Karmin Dave……..Date.07/01/2021

Guide to preparing a Participant Information Sheet

1. Give the name/title of the project

2. State who is working on the research project

3. State the purpose of the research project

4. Explain what is expected of participants

5. Explain how long it will take

6. Explain where the data will be collected

7. Explain what will happen to the information provided

8. Explain whether it is compulsory to participate

9. Explain whether participants can withdraw and how

10. Explain how participant privacy is to be protected

11. Explain whether participation will be acknowledged and how

12. Explain where research results will be made available

13. Supply details for participants who have any further enquires

Name of Researcher/s: Karmin Dave

Contact Details: kardav09@student.wintec.ac.nz, +64211606608

Date: 07/01/2021

Note: Consider carefully who your participants are and how best to communicate with them. Try to write the consent form in a language that is clear and correct, and that will be understood easily by your participants. Participants cannot consent to something that they do not understand.